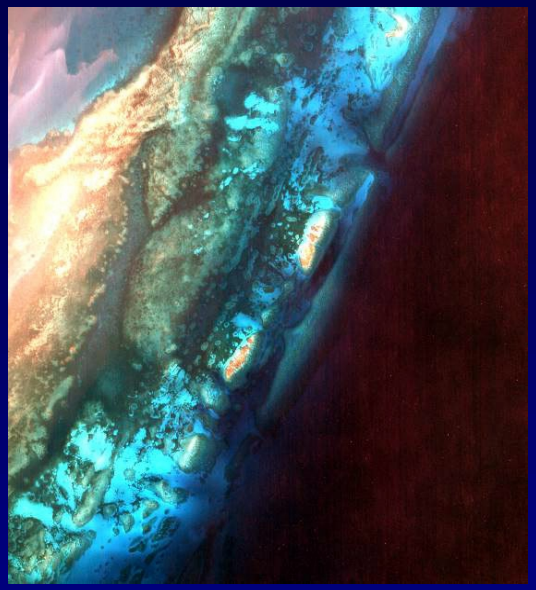
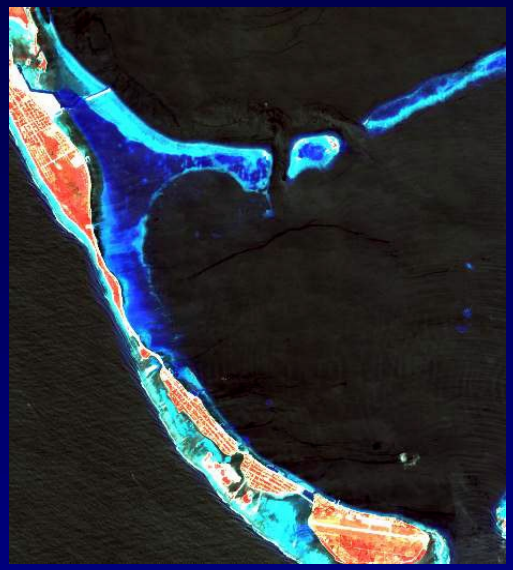
High resolution IKONOS data...





...for coral reefs studies

Serge Andrefouet
University of South Florida

High Spatial Resolution Commercial Imagery Workshop - Greenbelt March 2001

Frank Muller-Karger
David Palandro
Chuanmin Hu
Kendall Carder
(University of South Florida)

Eric Hochberg
(University of Hawaii)

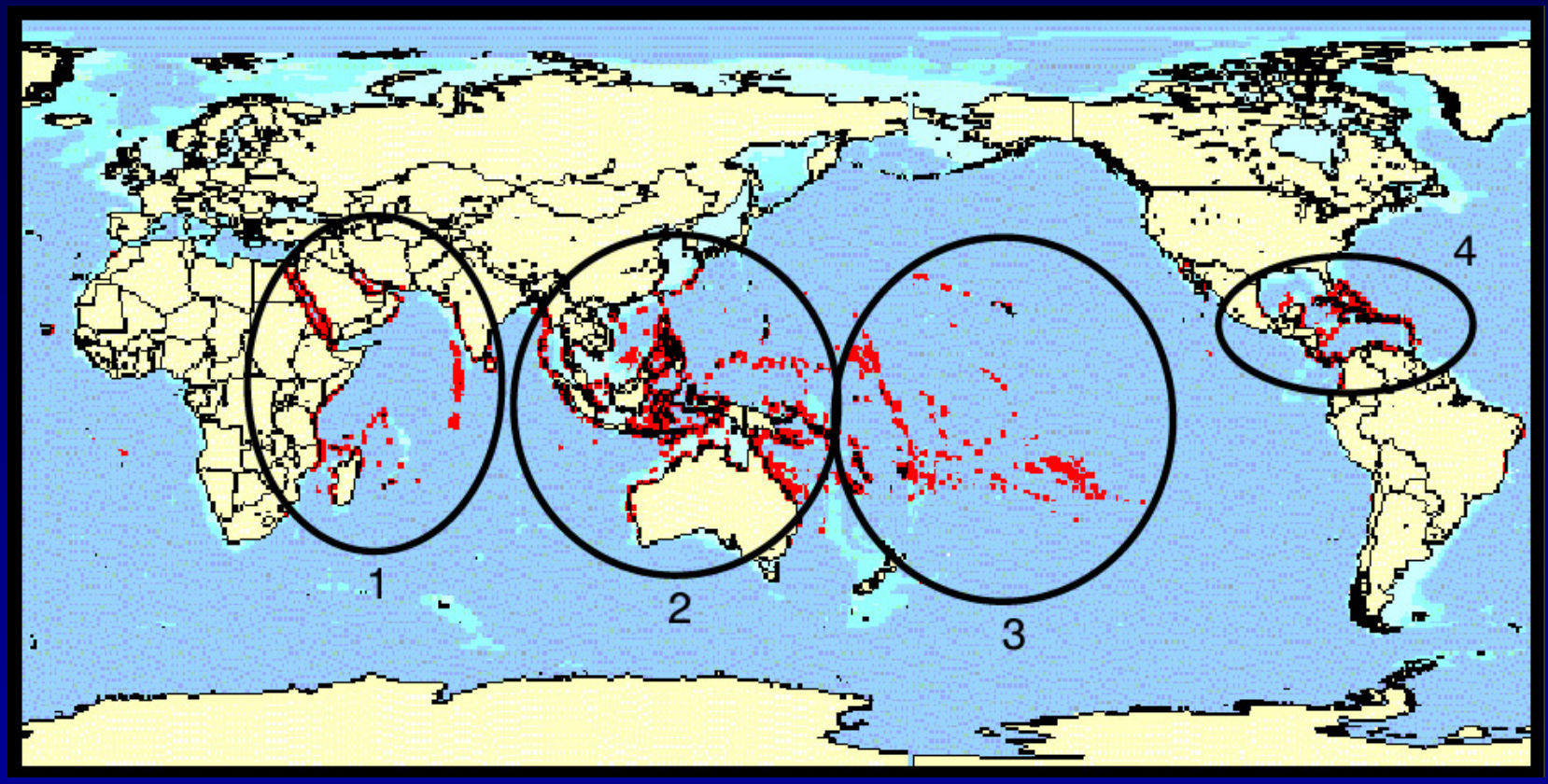
Jill Maeder
(University of Nebraska)

I. Coral reefs and remote sensing

II. Ikonos applications

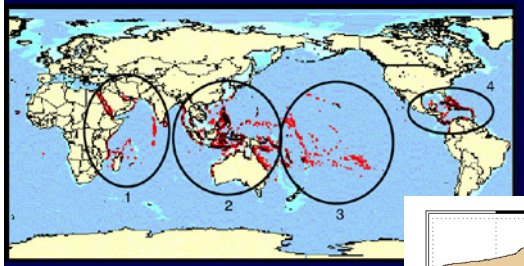
I. Coral reefs and remote sensing

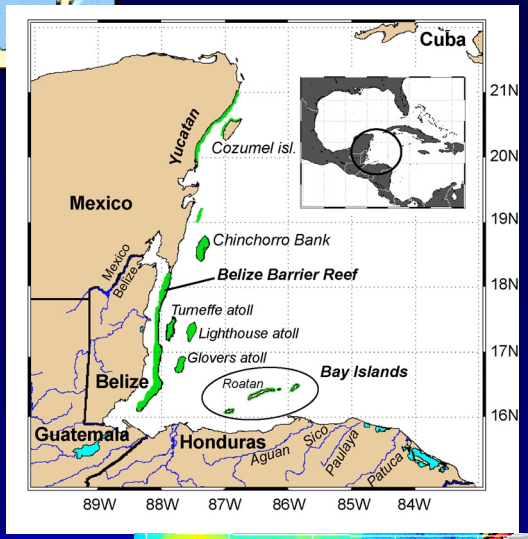
Location of Coral Reefs



4 main biogeographic regions

Scales...

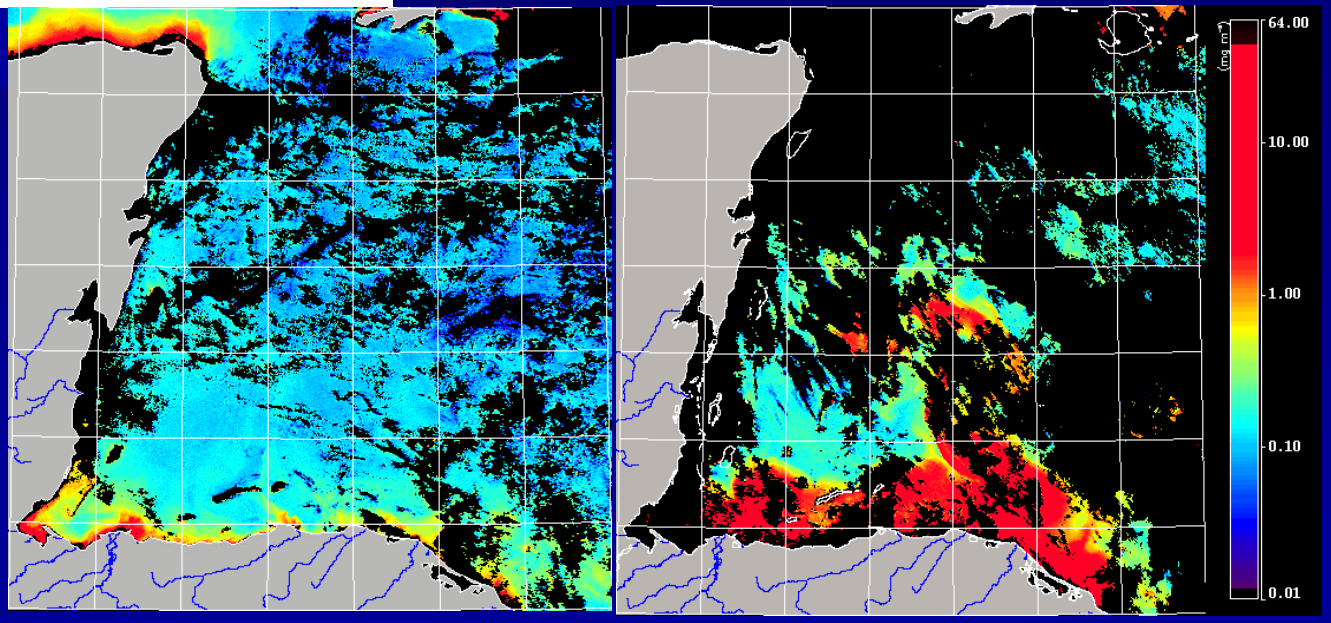


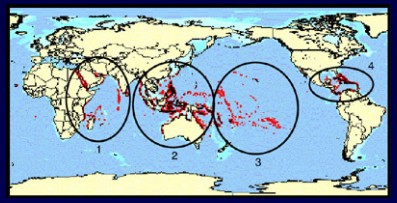


Regional scale:
Oceanic sensors niche

Meso-American
Reef System

- Connectivity
- Water quality

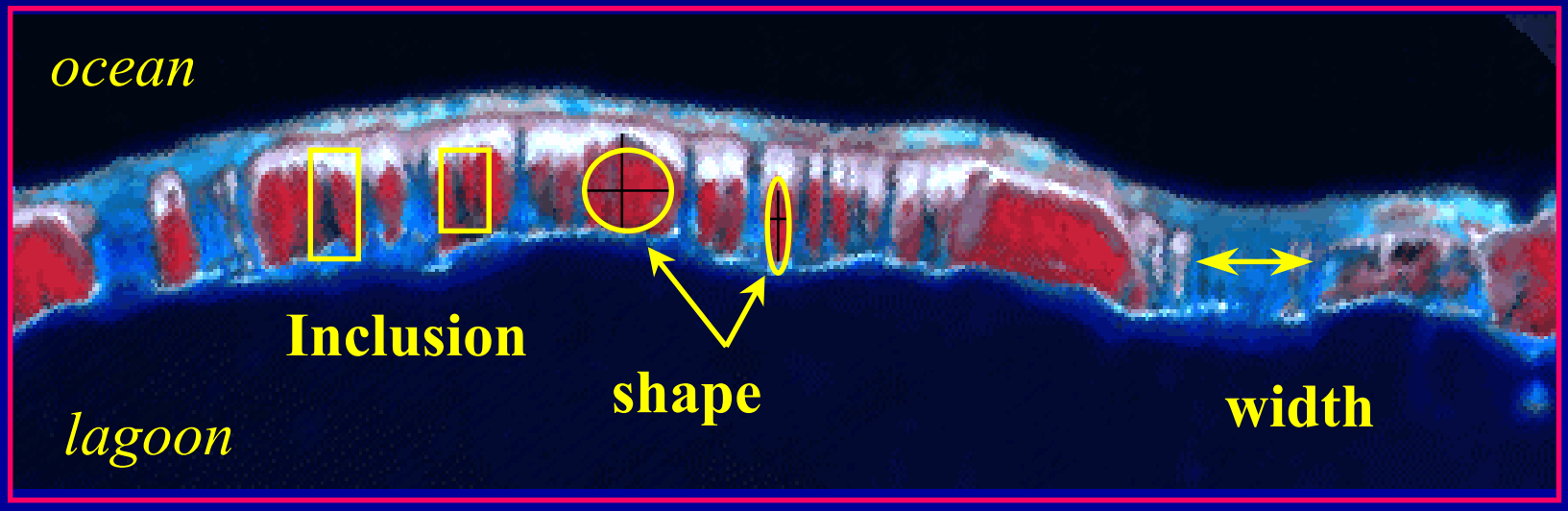


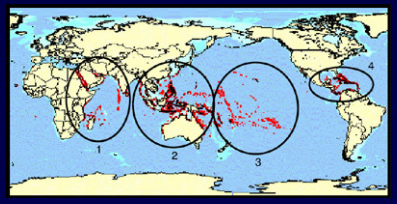


...Scales...

Landscape scale:
Landsat TM, ETM+
SPOT XS-P niche

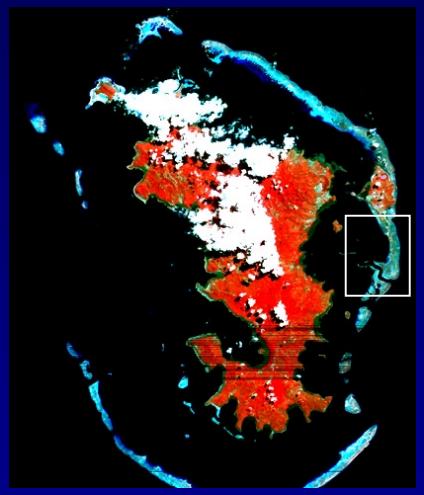
e.g Pacific atolls
- Spatial structure
- Climate forcing



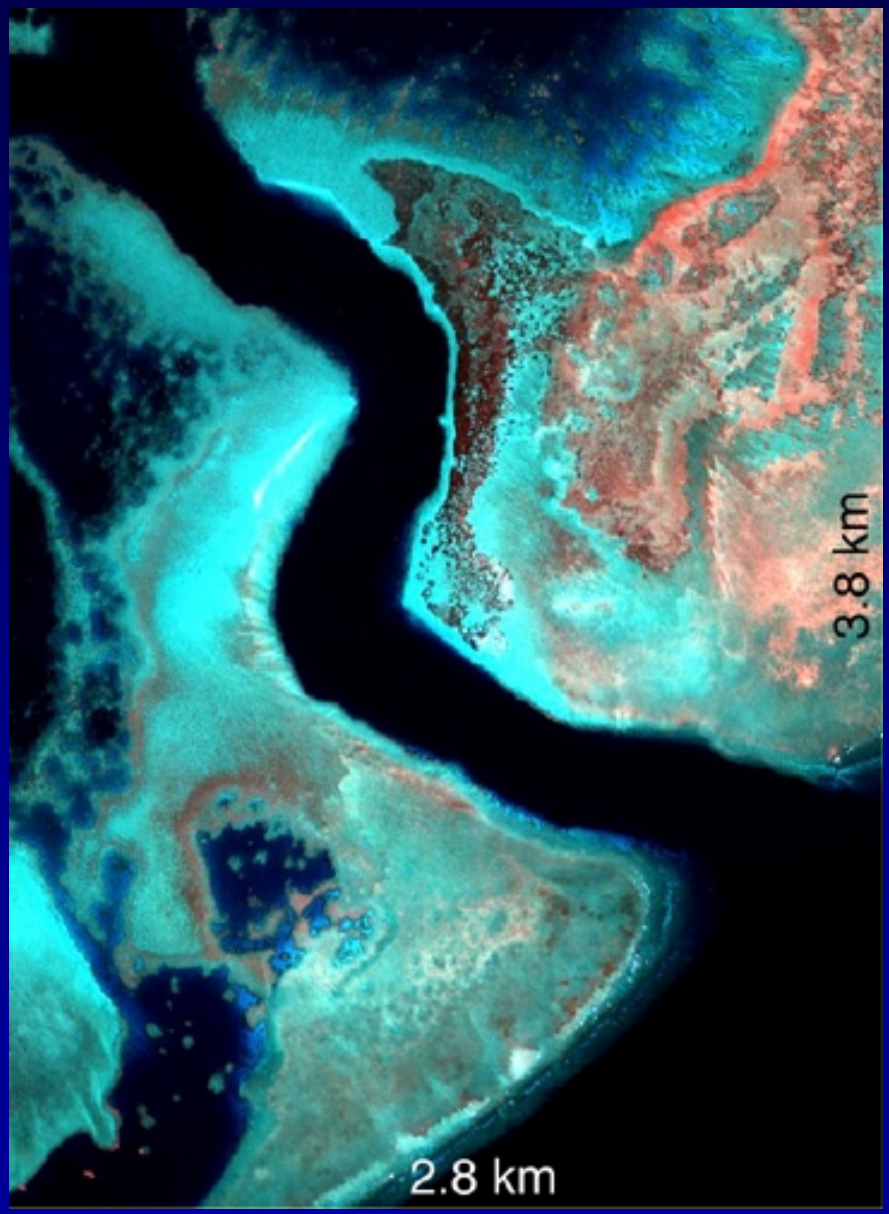


...Scales...

Biological communities scale:
Hyperspectral, IKONOS niche

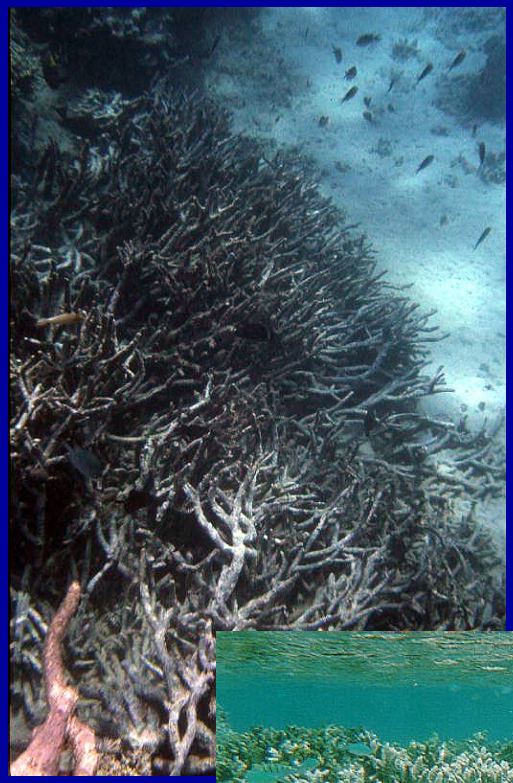


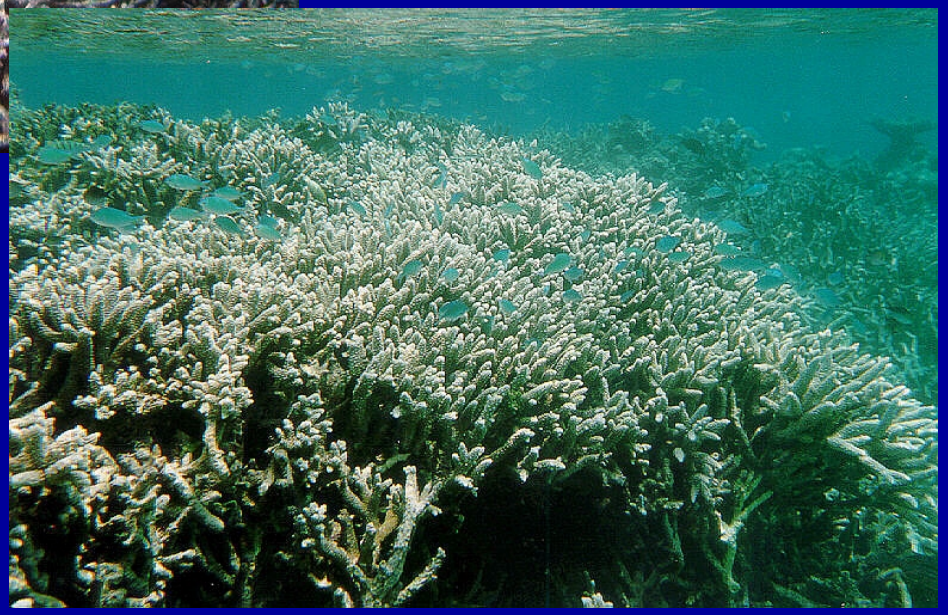
e.g.: Indian Ocean Reefs
- Spatial structure
- Inventories
- Change detection
- Biophysical measurements



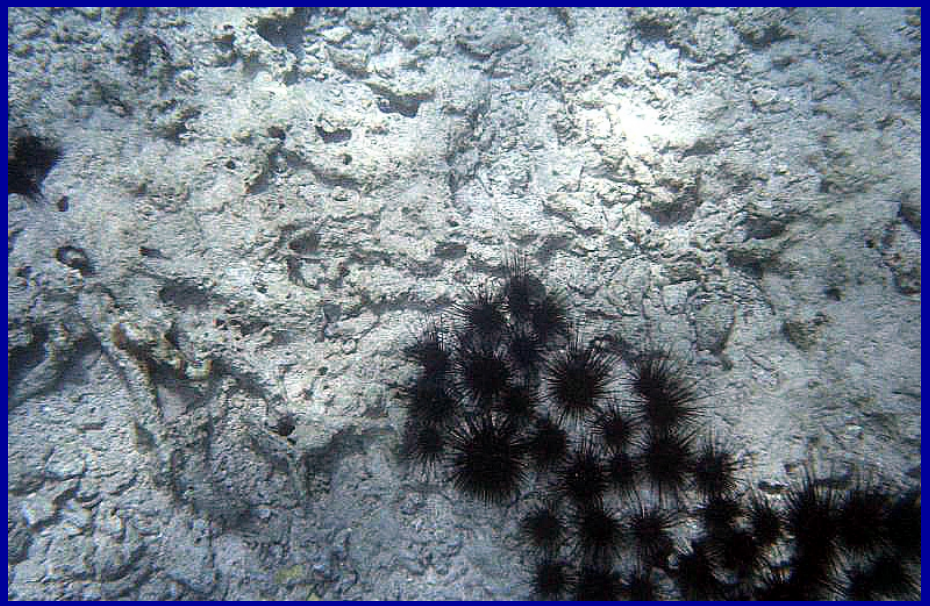
Biological communities in coral reefs environment

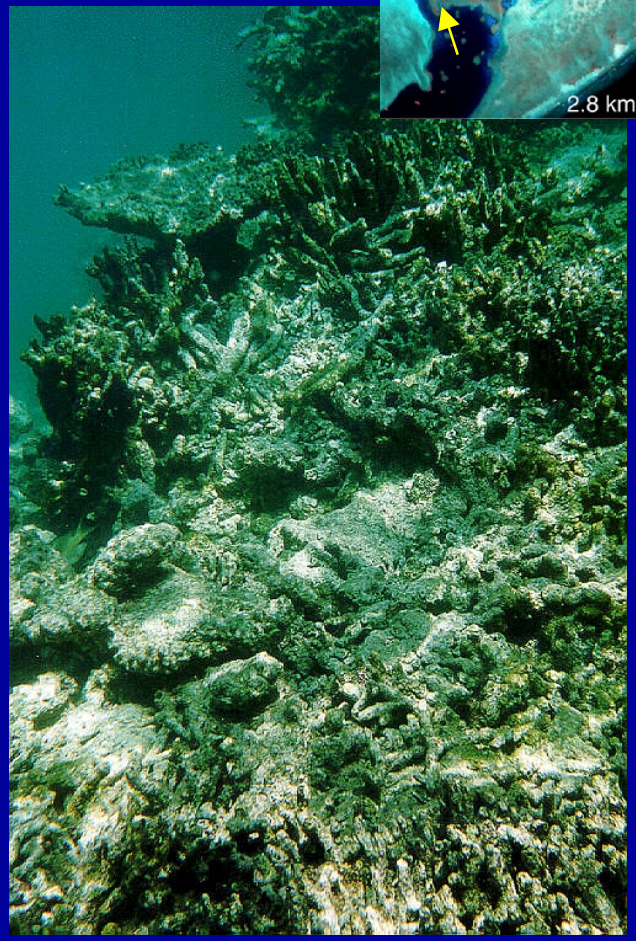
Reef-builders: corals, coralline





Dead substrates

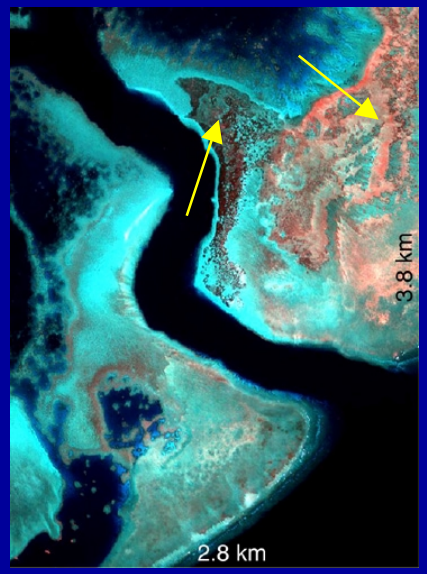




Algae

Heterogeneous

Seagrass beds



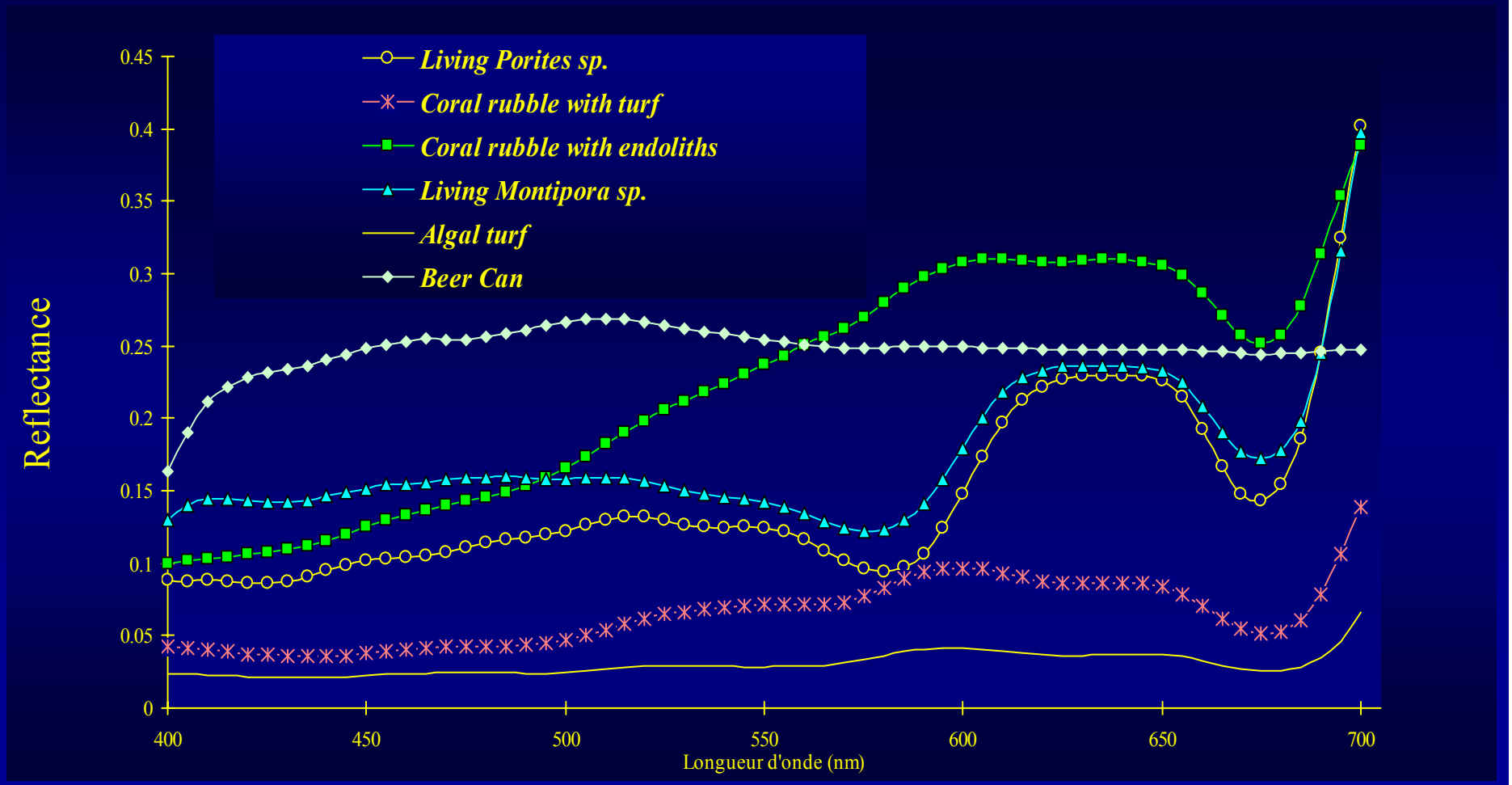
II. Ikonos Applications

Potential

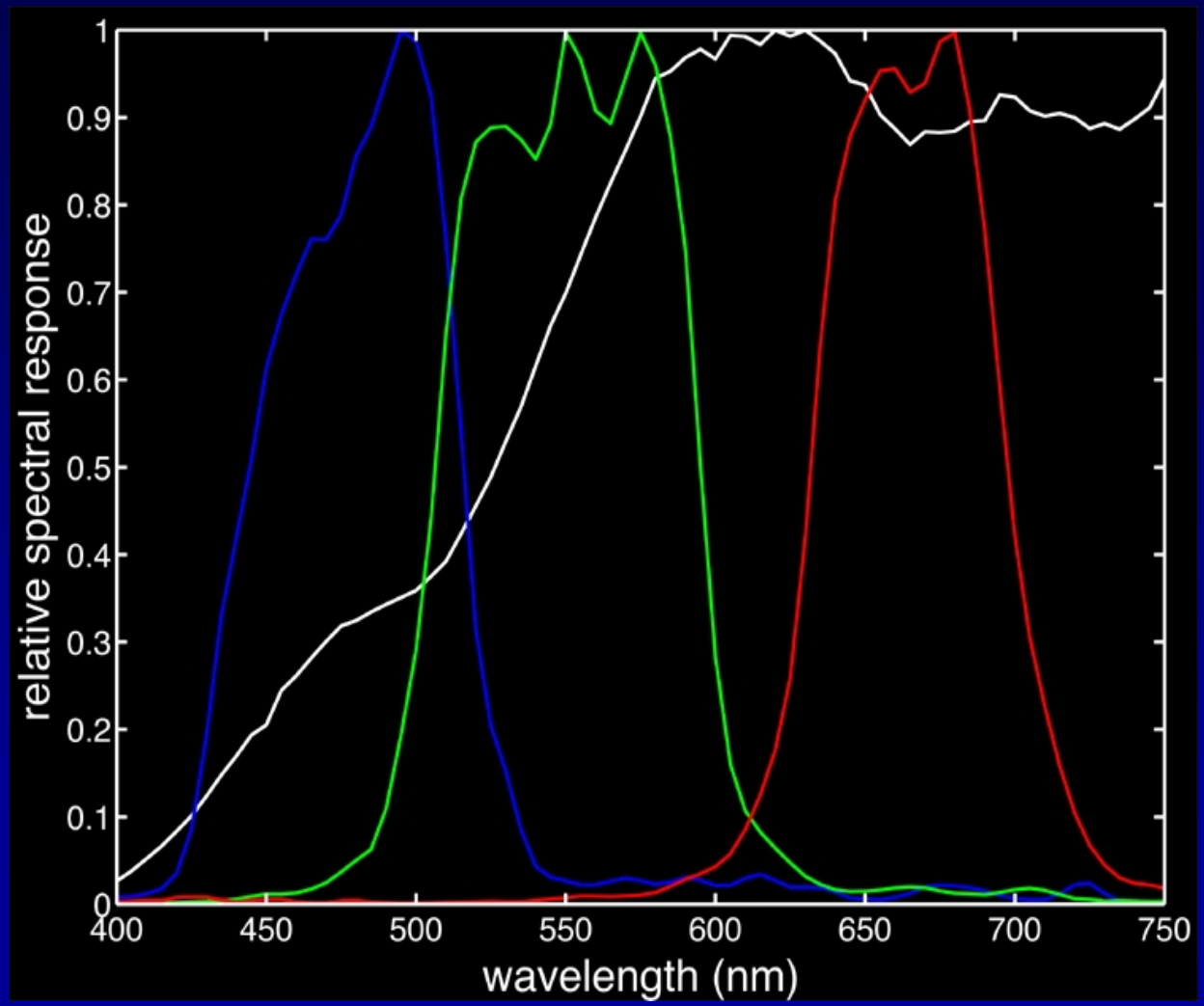
Spectral

Spatial

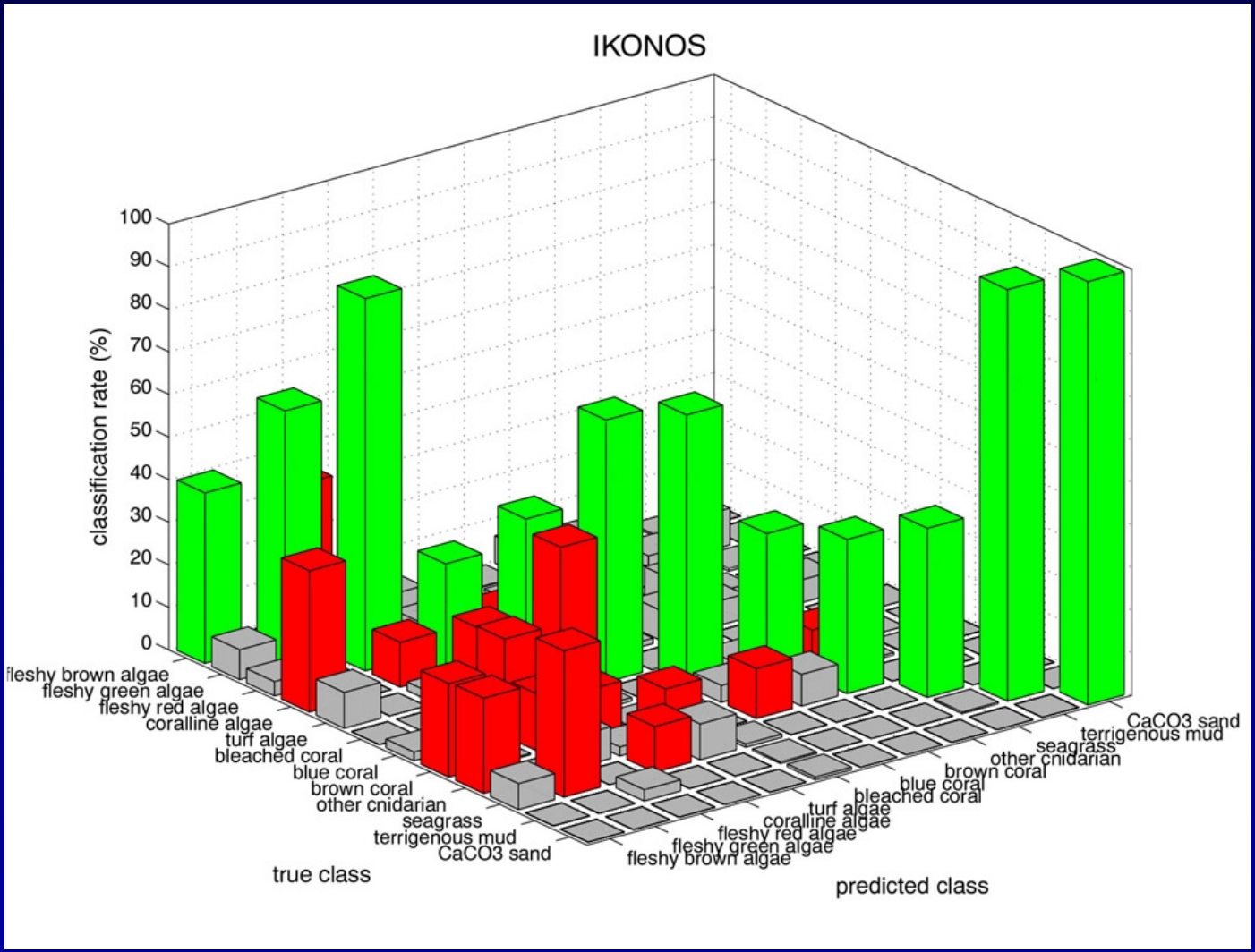
Spectral signatures



RSR IKONOS

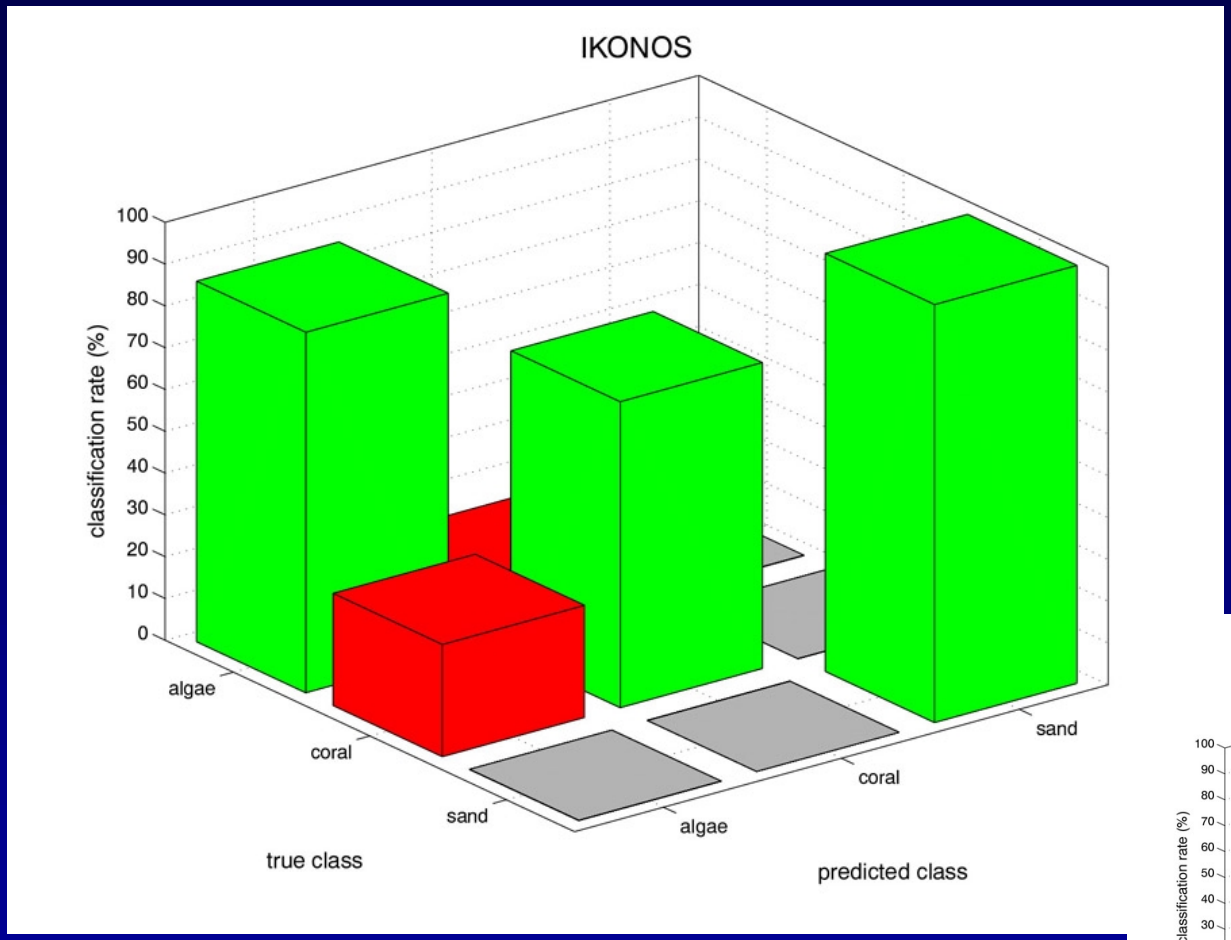

relative spectral response
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
450
500
550
600
650
700
750
wavelength (nm)

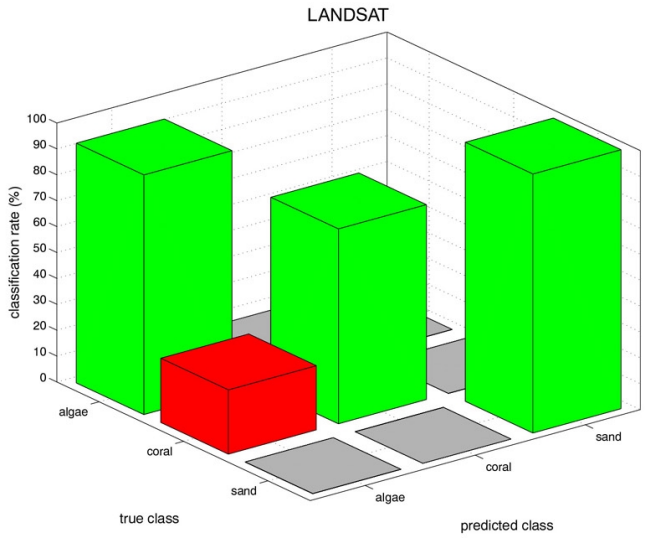
Classification of spectra : 12 classes,
~6000 spectra for training, ~6000 spectra for control



(Data: Eric Hochberg, UH)

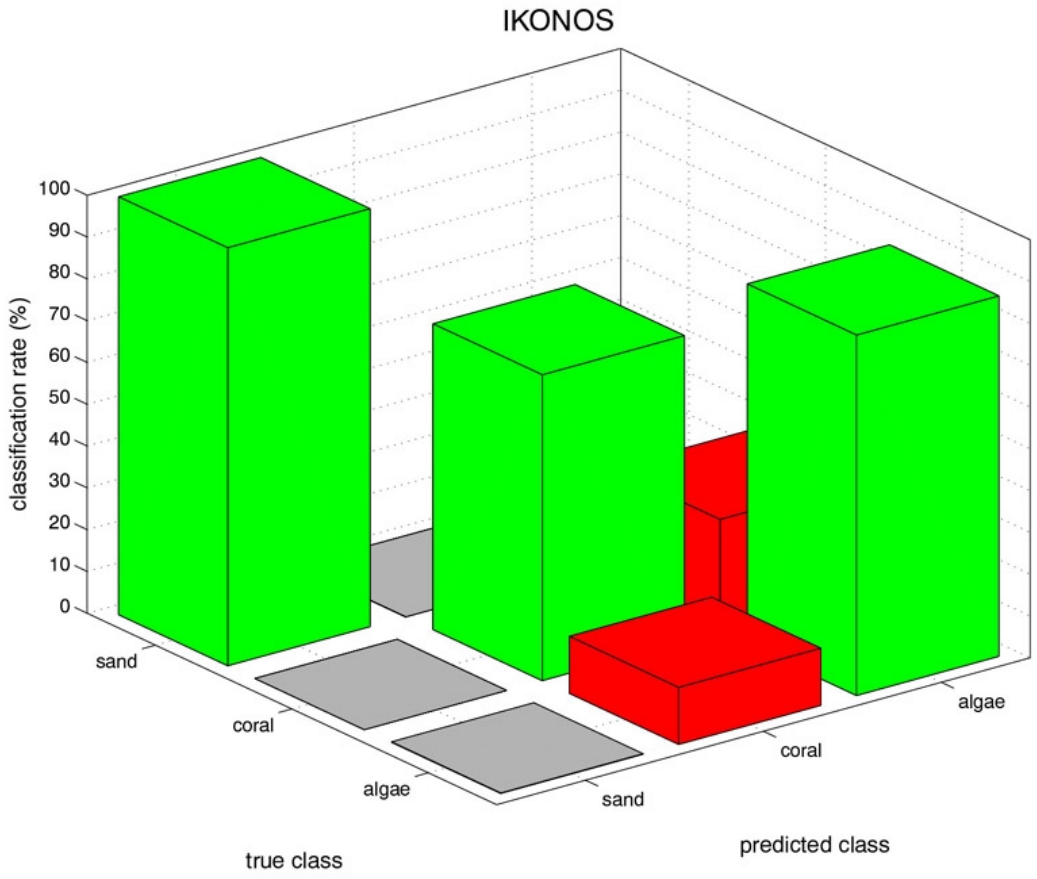
Classification of spectra: 3 classes

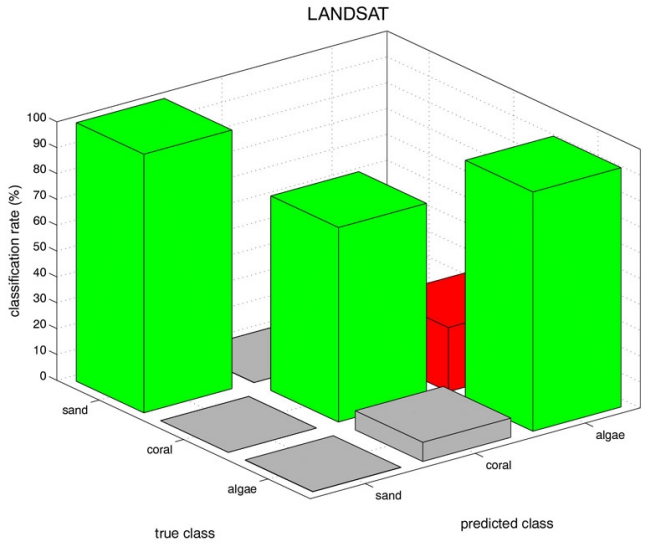




(Data: Eric Hochberg, UH)

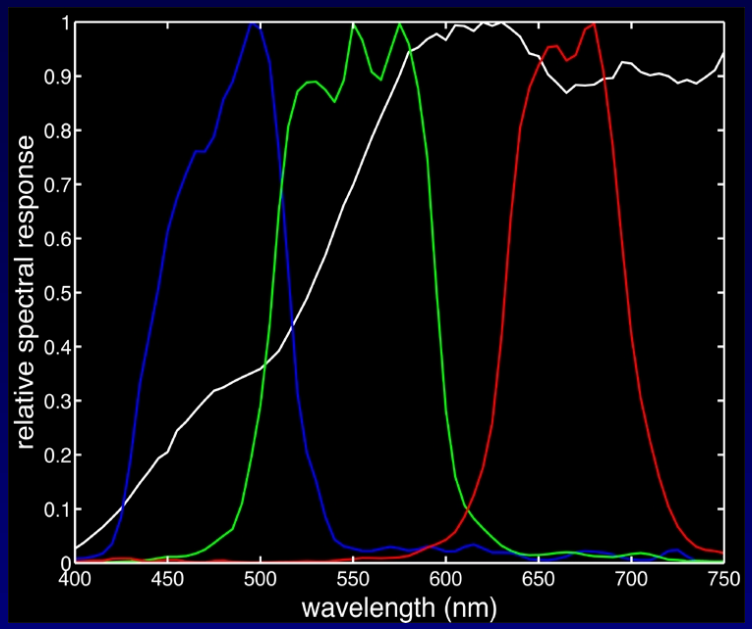
Classification of spectra: 3 classes

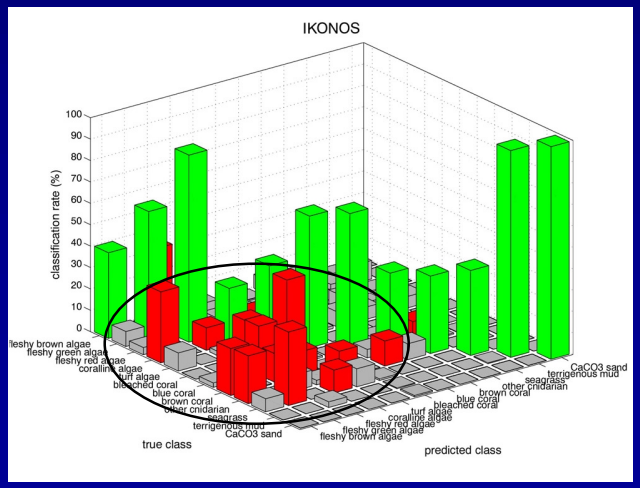


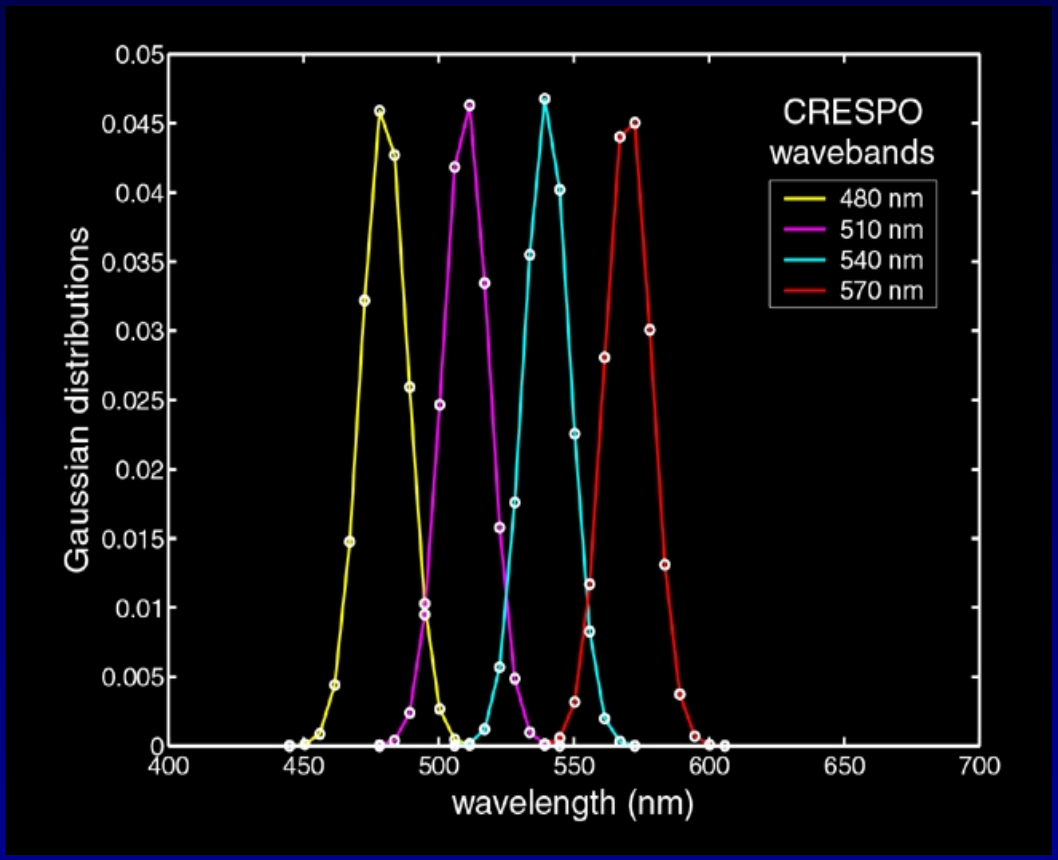


(Data: Eric Hochberg, UH)

IKONOS

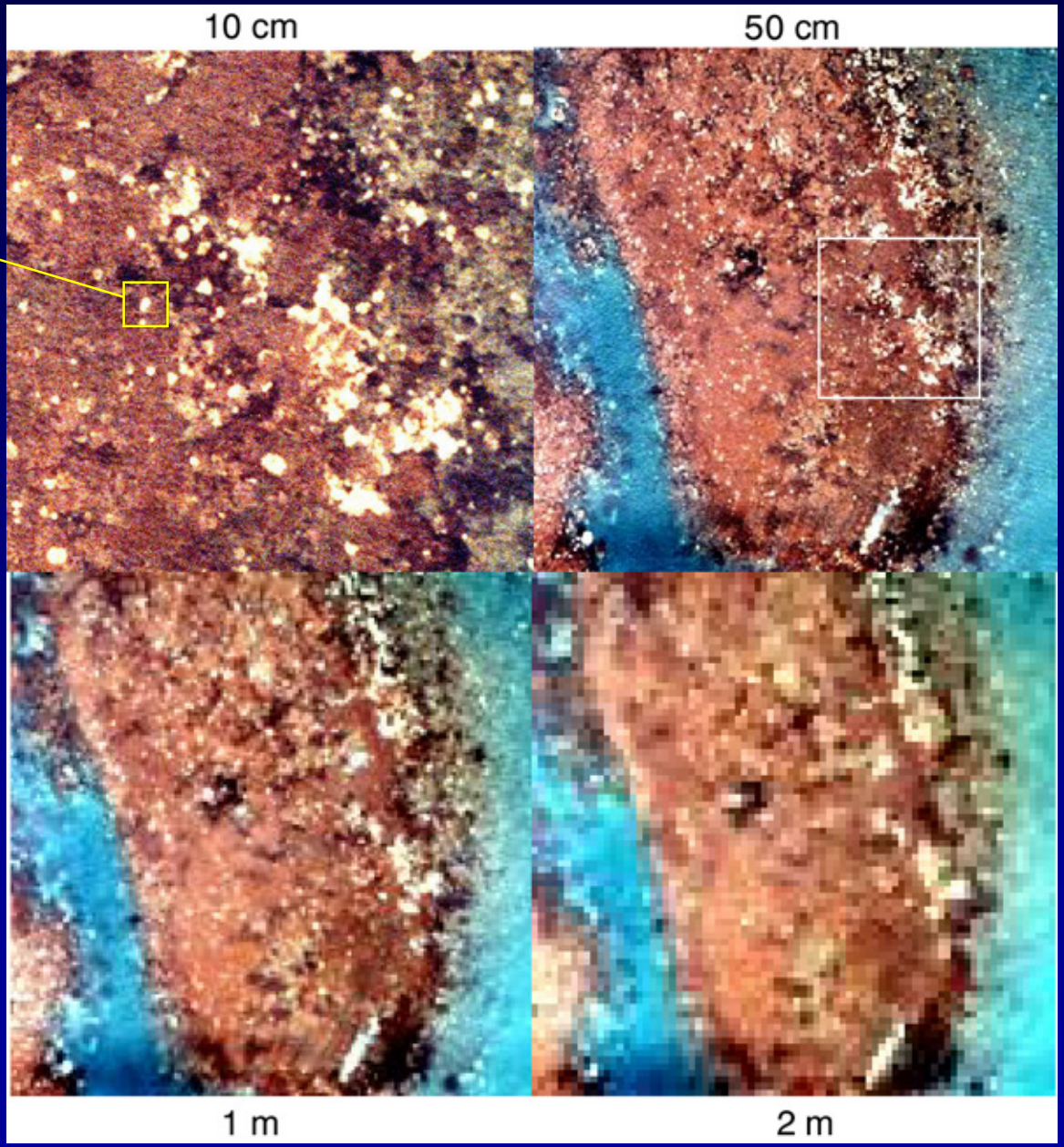






University Hawaii: Coral Reef Spectrophotometric Observatory, NASA's University Earth System Science Program: definition of ideal wavebands to optimize classification results

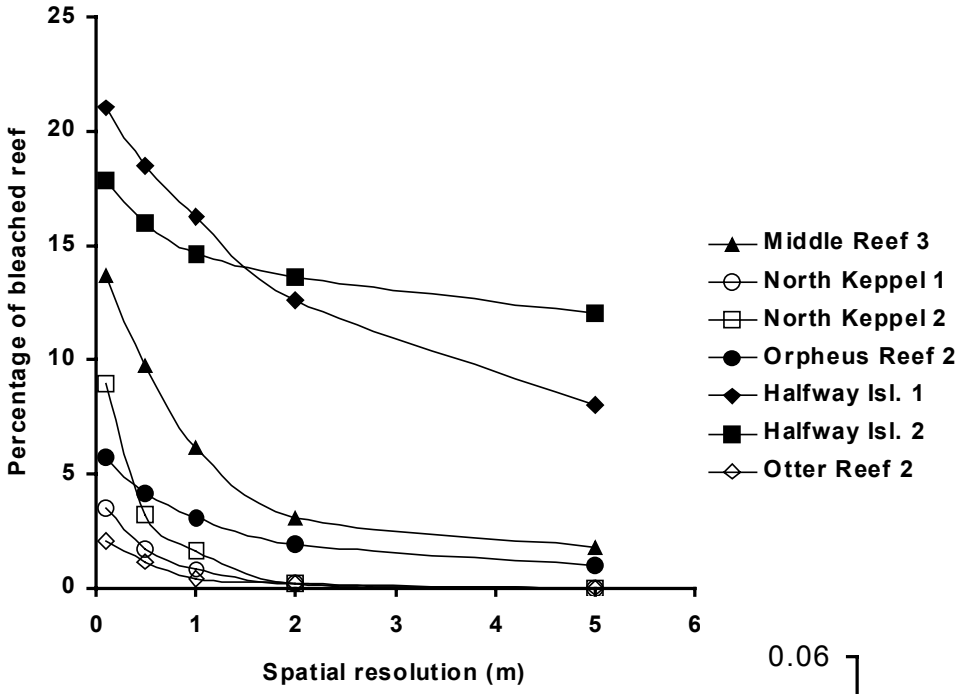
Spatial resolution for community-scale studies



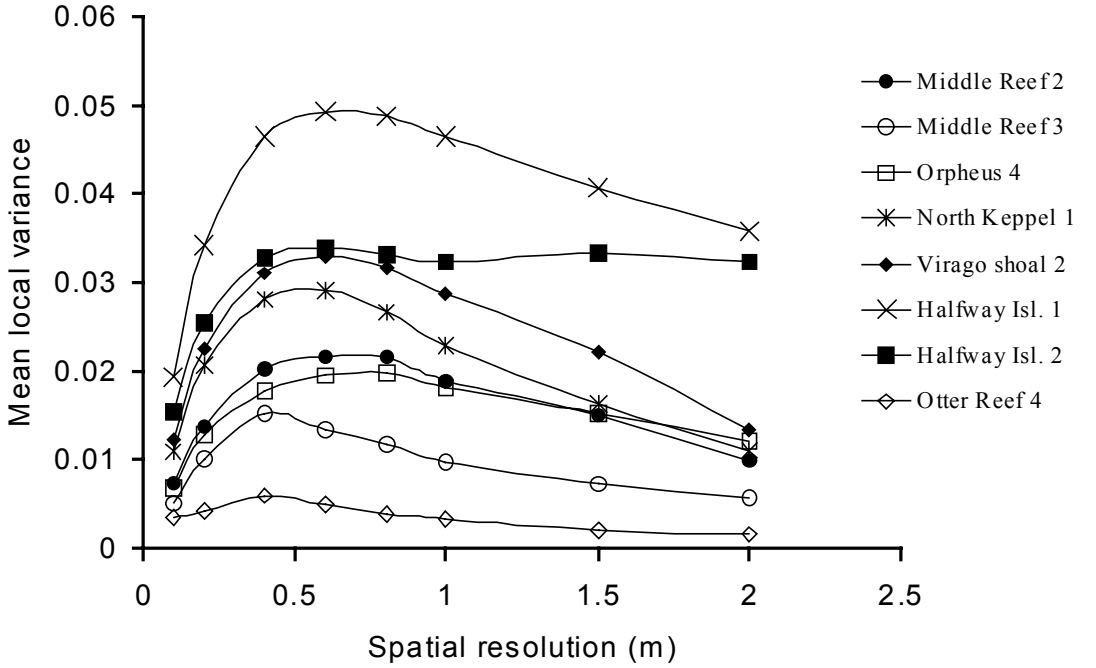
e.g.:
Aerial photos,
Great Barrier Reef, 1998

Influence of spatial resolution
on coral bleaching detection

Bleaching detected *vs* resolution



Ref: Andréfouët S, Berkelmans R, Odriozola L. Done T., Oliver J. Muller-Karger F. Choosing the appropriate spatial resolution for remote sensing of coral bleaching events. Submitted Coral Reefs.



Optimal resolution: peak of local variance

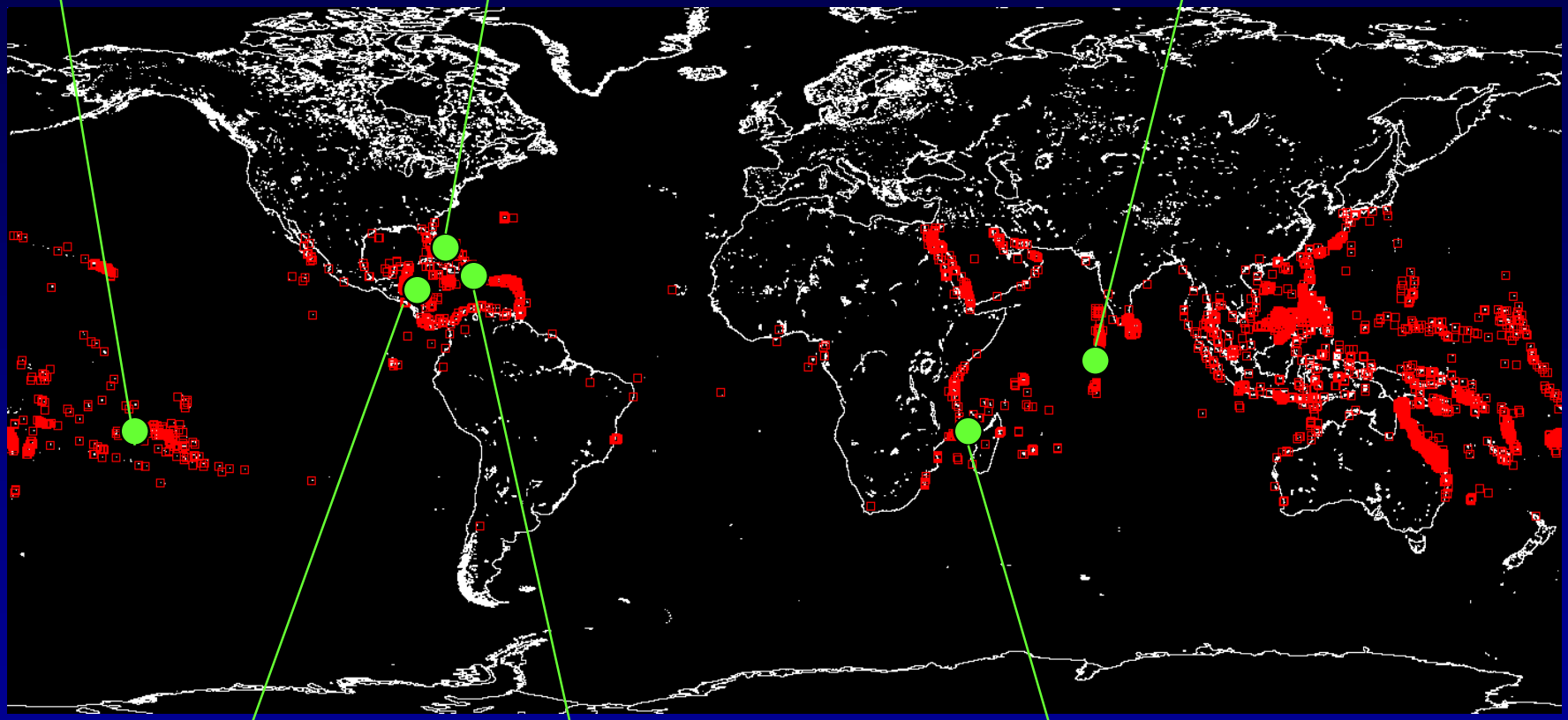
Community level studies using IKONOS

- Inventory

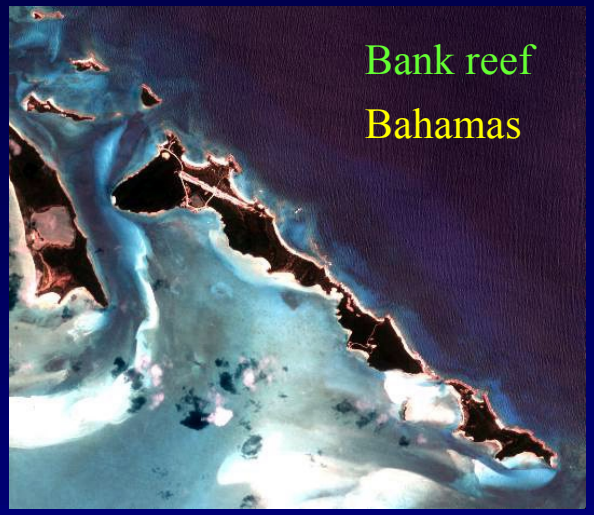
- Change detection

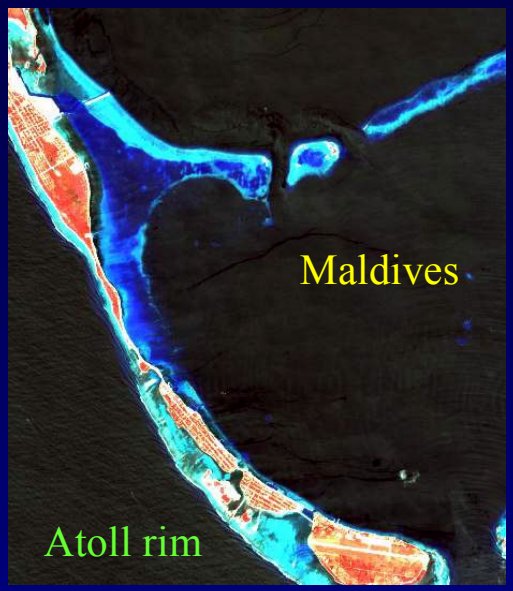
- Biophysical measurement

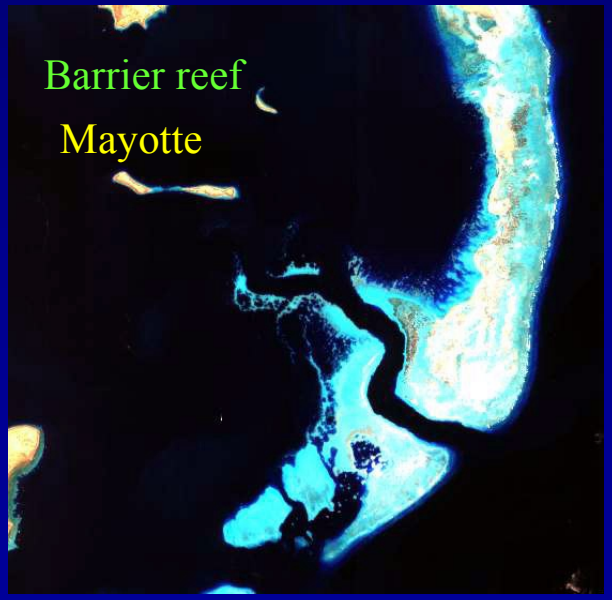
NASA Scientific Data Purchase (Acquired -->Nov 2000)



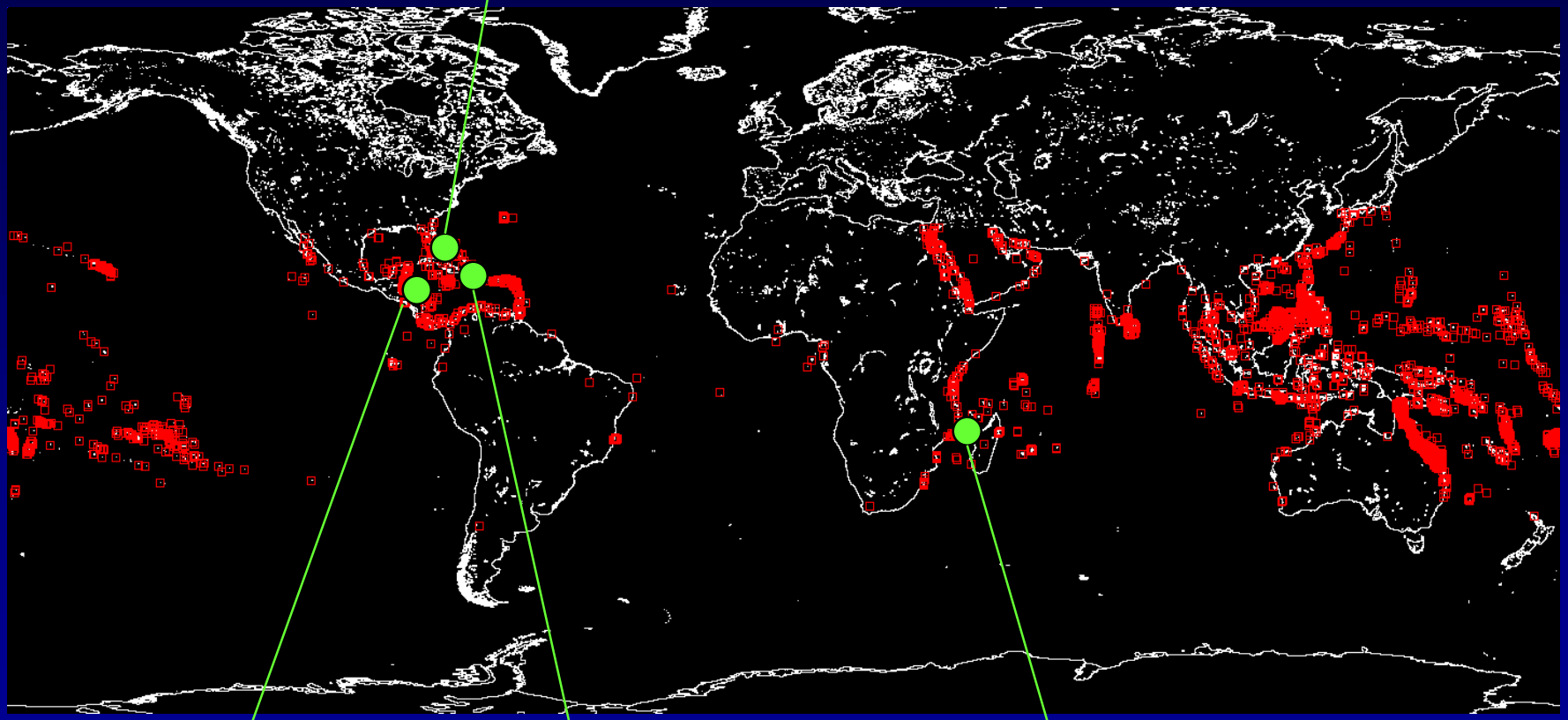
NASA Scientific Data Purchase







NASA Scientific Data Purchase (Approved February 2001)



Criteria for tasking requests

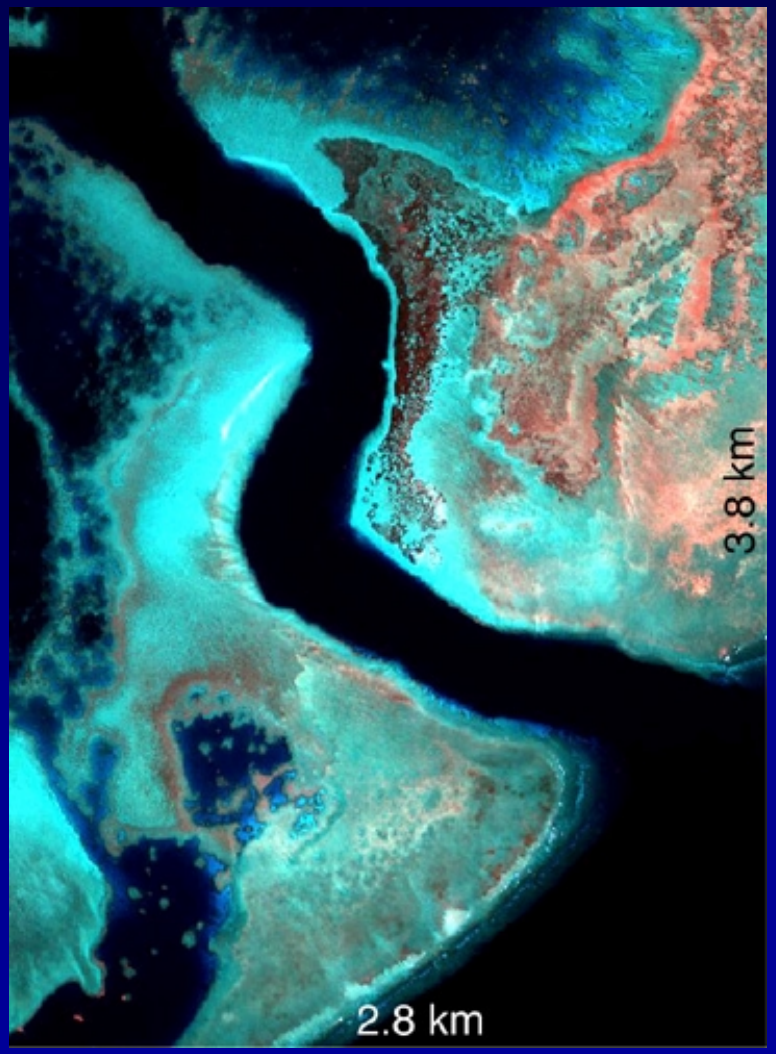
Cooperation with US/international institutions providing:

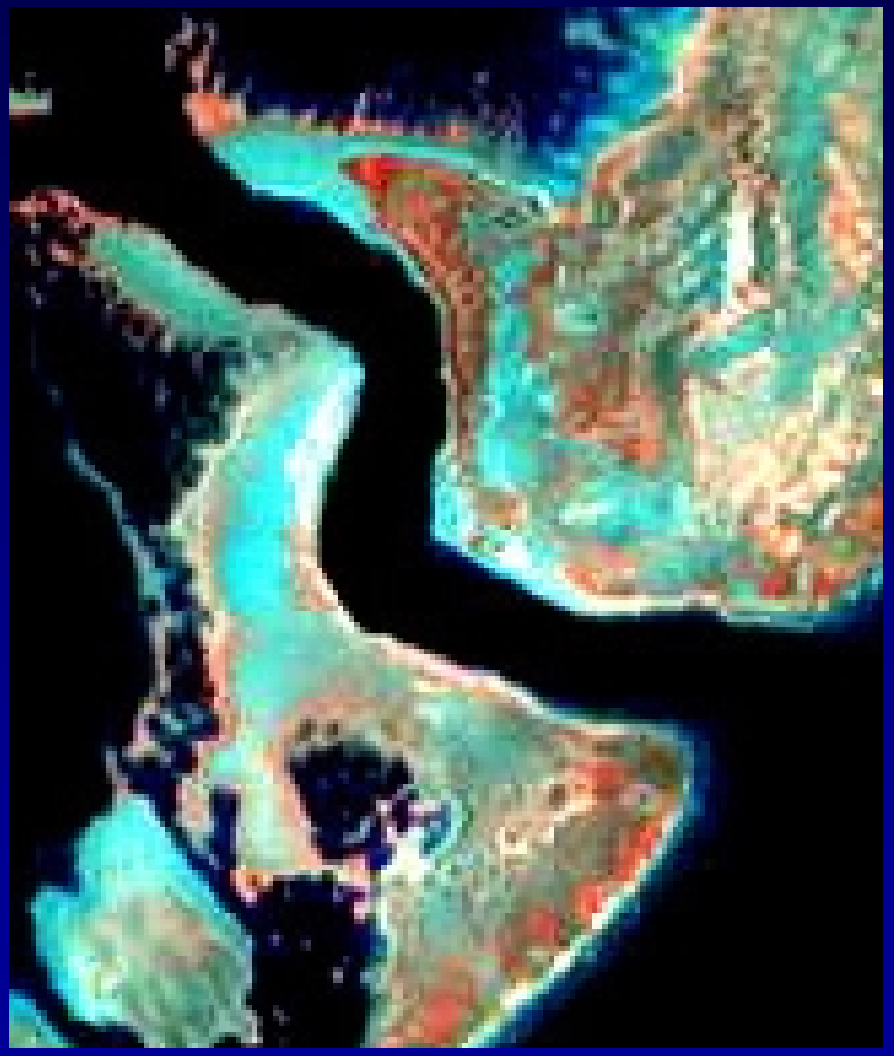
- ground-truthing data
- other data sets (SPOT, LANDAT, hyperspectral)
- references (publications, reports,….)
- scientific question

- level of products (never Precision)

Inventories

-Scaling SPOT and Landsat 7 ETM+ data

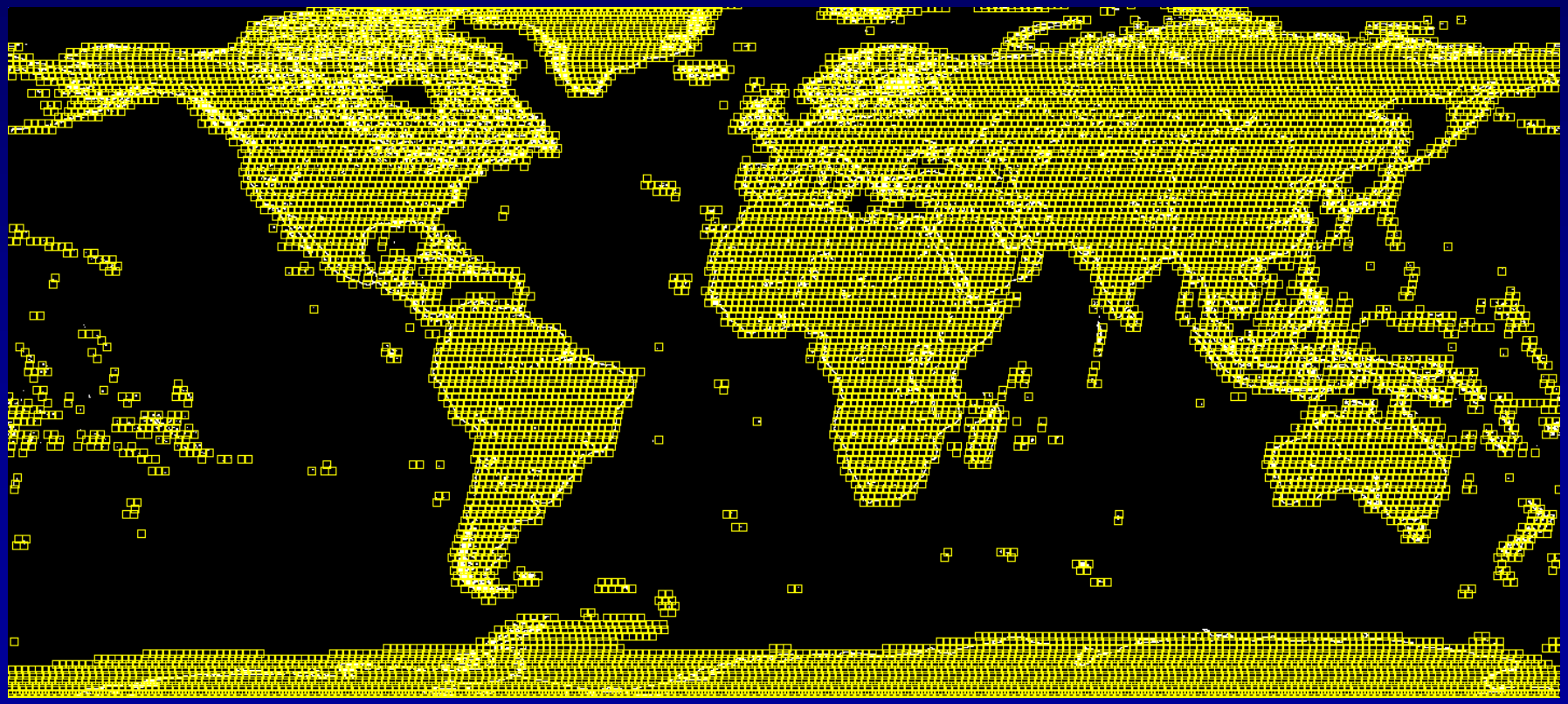




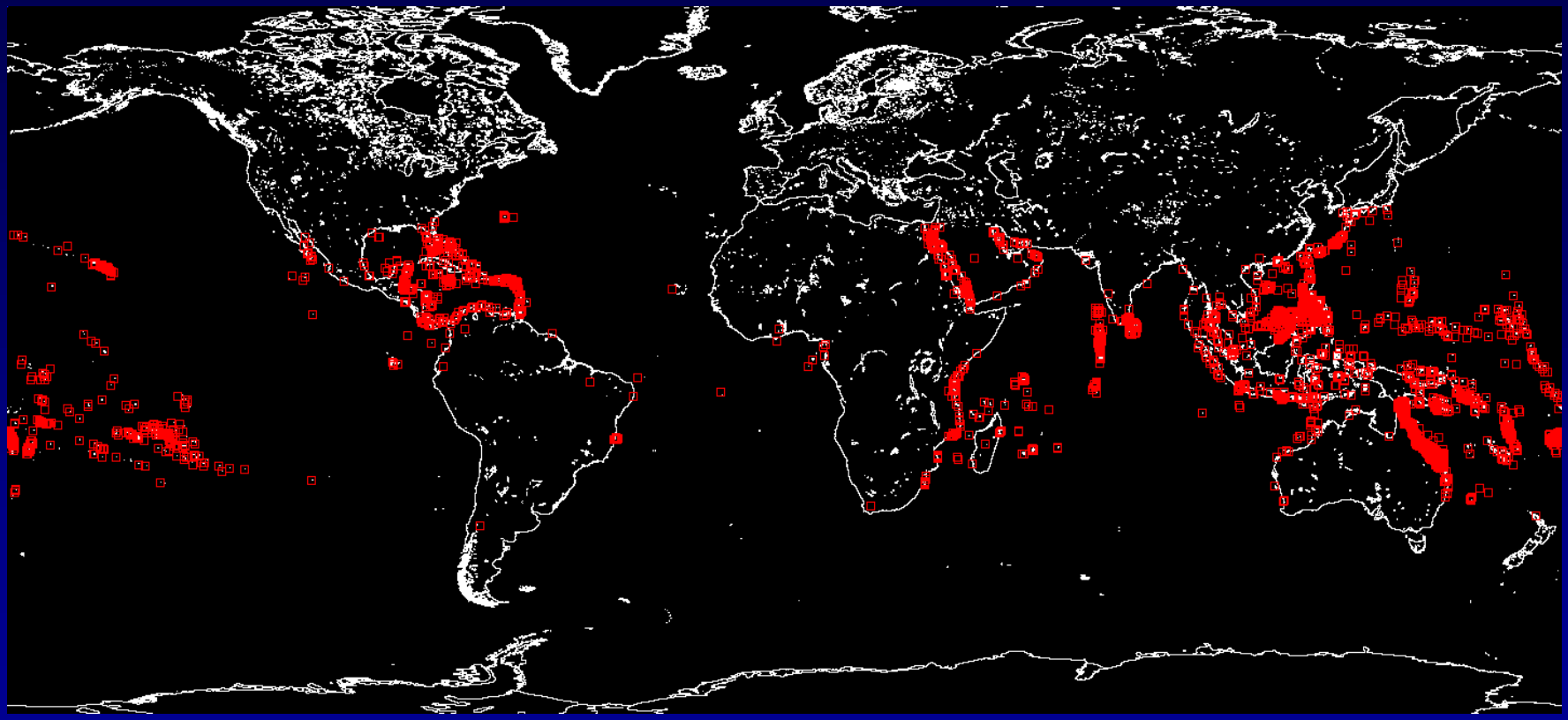
Global Coverage: NASA collects ~200 LANDSAT 7 images per day worldwide:

Long-Term Acquisition Plan

(LTAP)

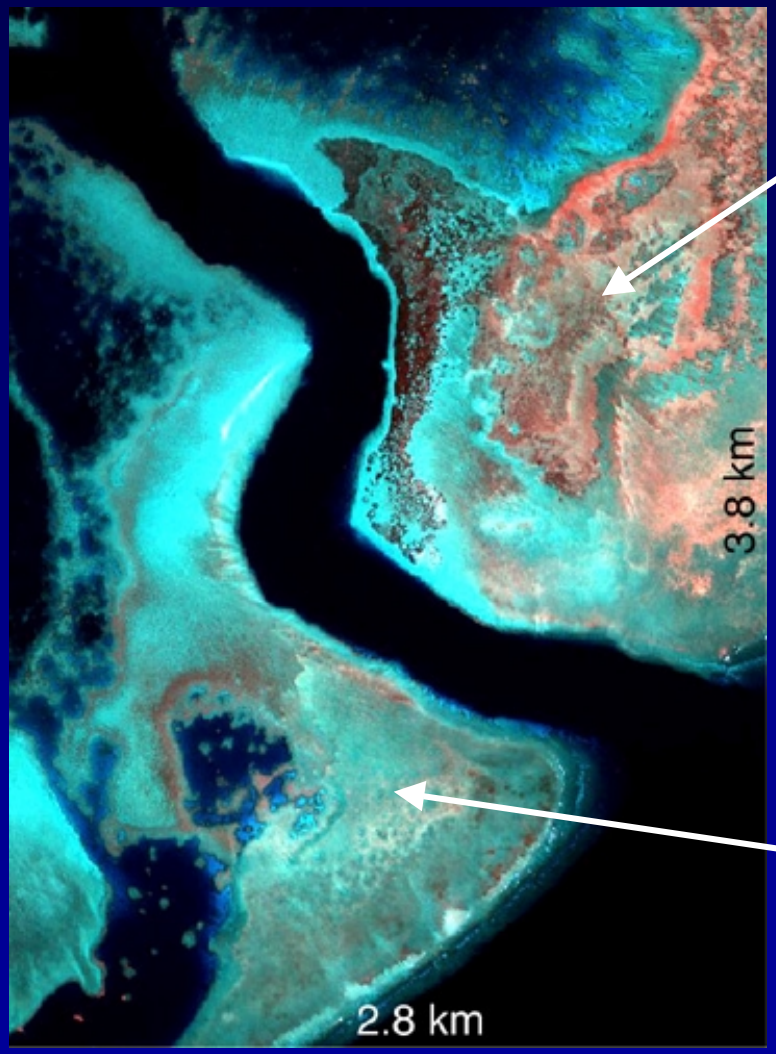


Complete coverage of coral reefs



Scaling results

Mayotte

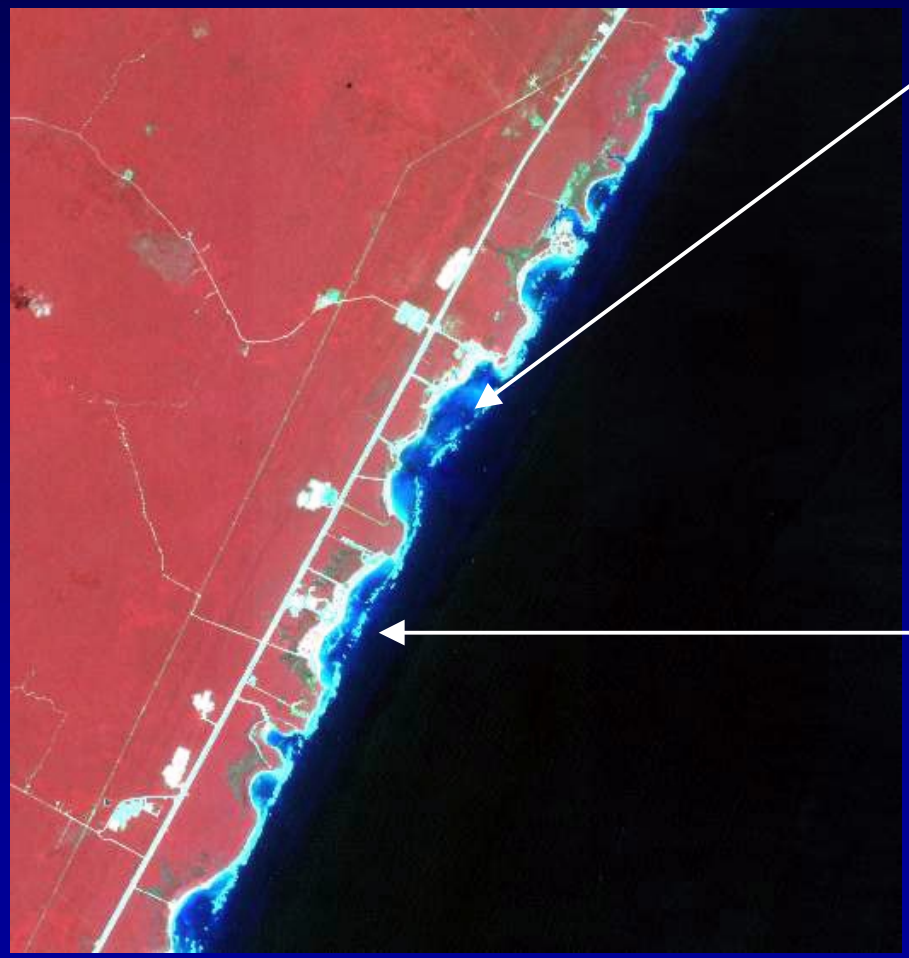


Seagrass/algae dominated reef flat

Heterogeneous reef flat
without seagrass

Scaling results

Mexico



Seagrass dominated shallow reef flat

Coral dominated slope

Scaling results

Mayotte	SPOT	IKONOS
dense seagrass	12	11
diffuse seagrass	24	23
sand	18	22
brown algae	9	2
coralline	0	8
heterogeneous 1	12	11
heterogeneous 2	13	10
coral margin	8	4
micro-atolls	0	4
coral patches	4	5
Total	100	100

Mexico	LANDSAT	IKONOS
dense seagrass	20	23
diffuse seagrass	28	23
sand	21	23
crest	0	4
coral margin	18	12
spur and grooves	13	0
Total	100	85

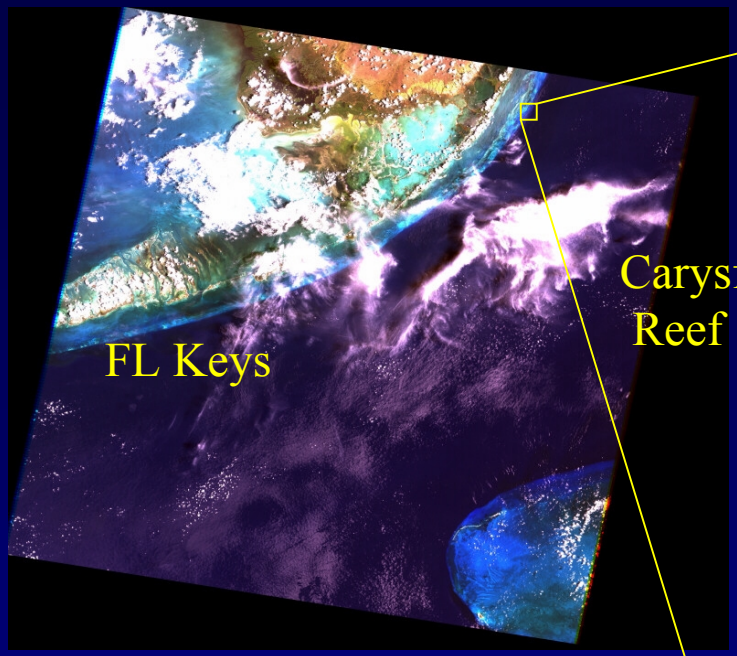
IKONOS captures small specific communities not accessible to Landsat/SPOT

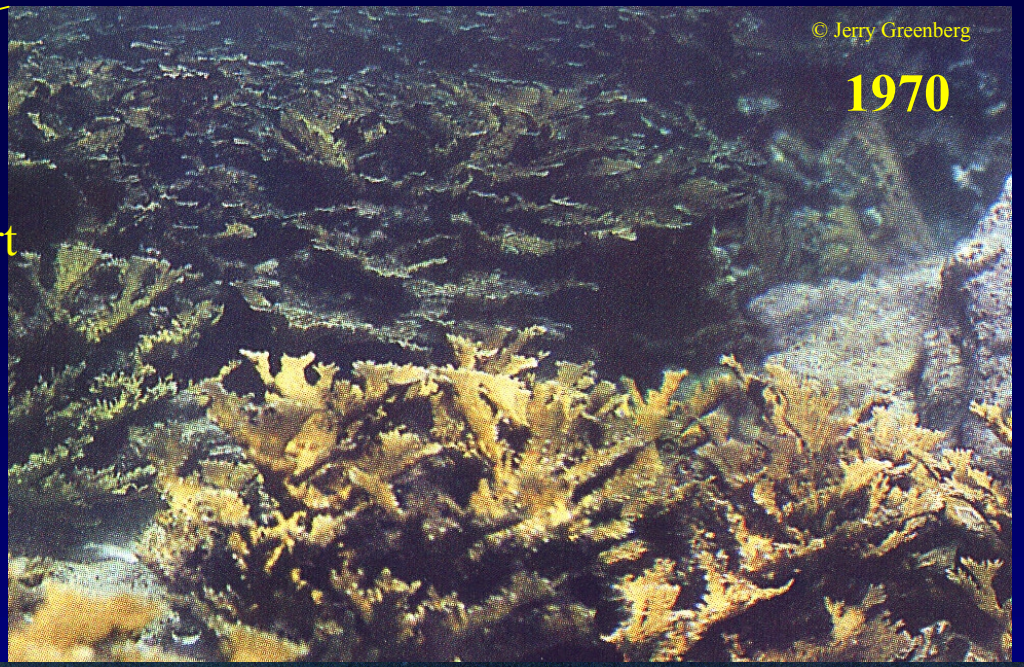
For some scenes, IKONOS does not provide information at depth (SNR, geometry)

Scaling results

Needs to be tested on a large variety of sites

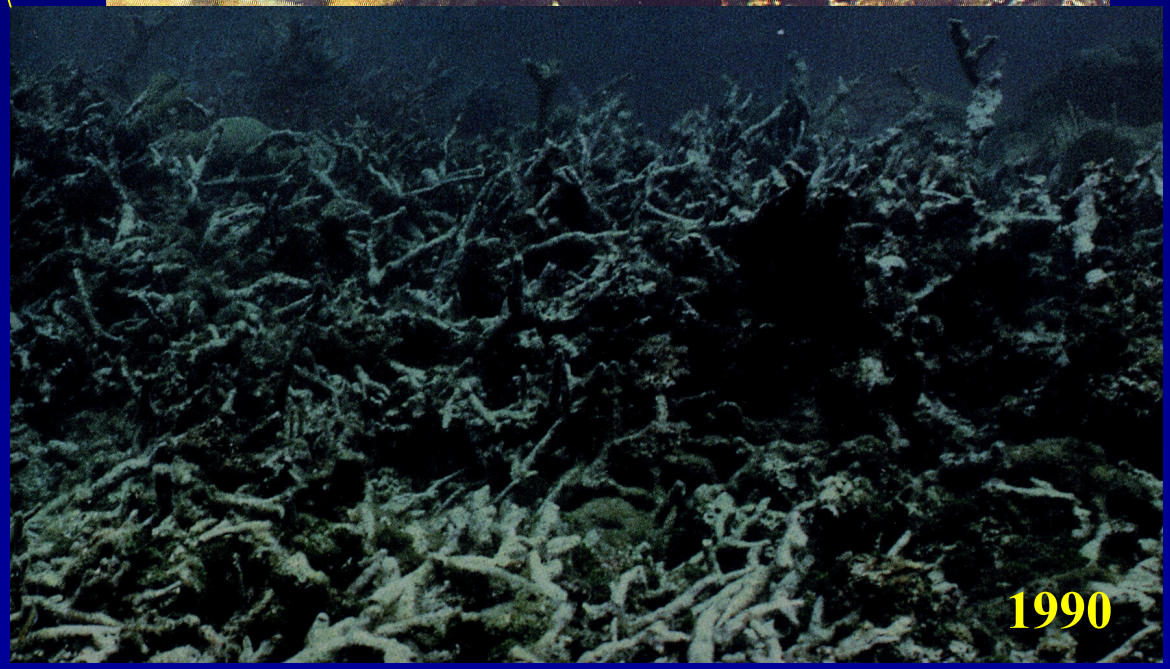
Recommendations for Landsat Data Continuity Mission and L8 specifications



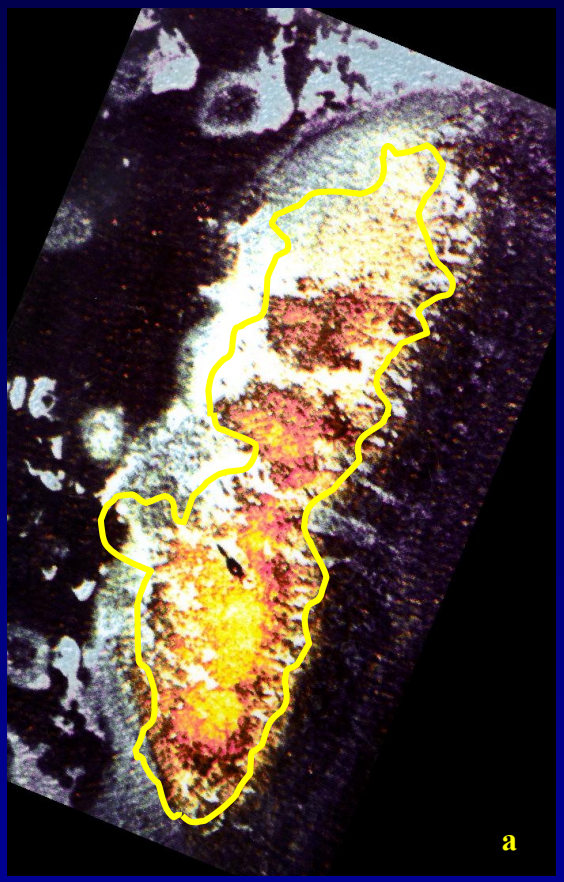


Change detection

- hurricane impact
- coral mortality
- phase-shift
- strategy-shift
- fragmentation



High resolution change detection



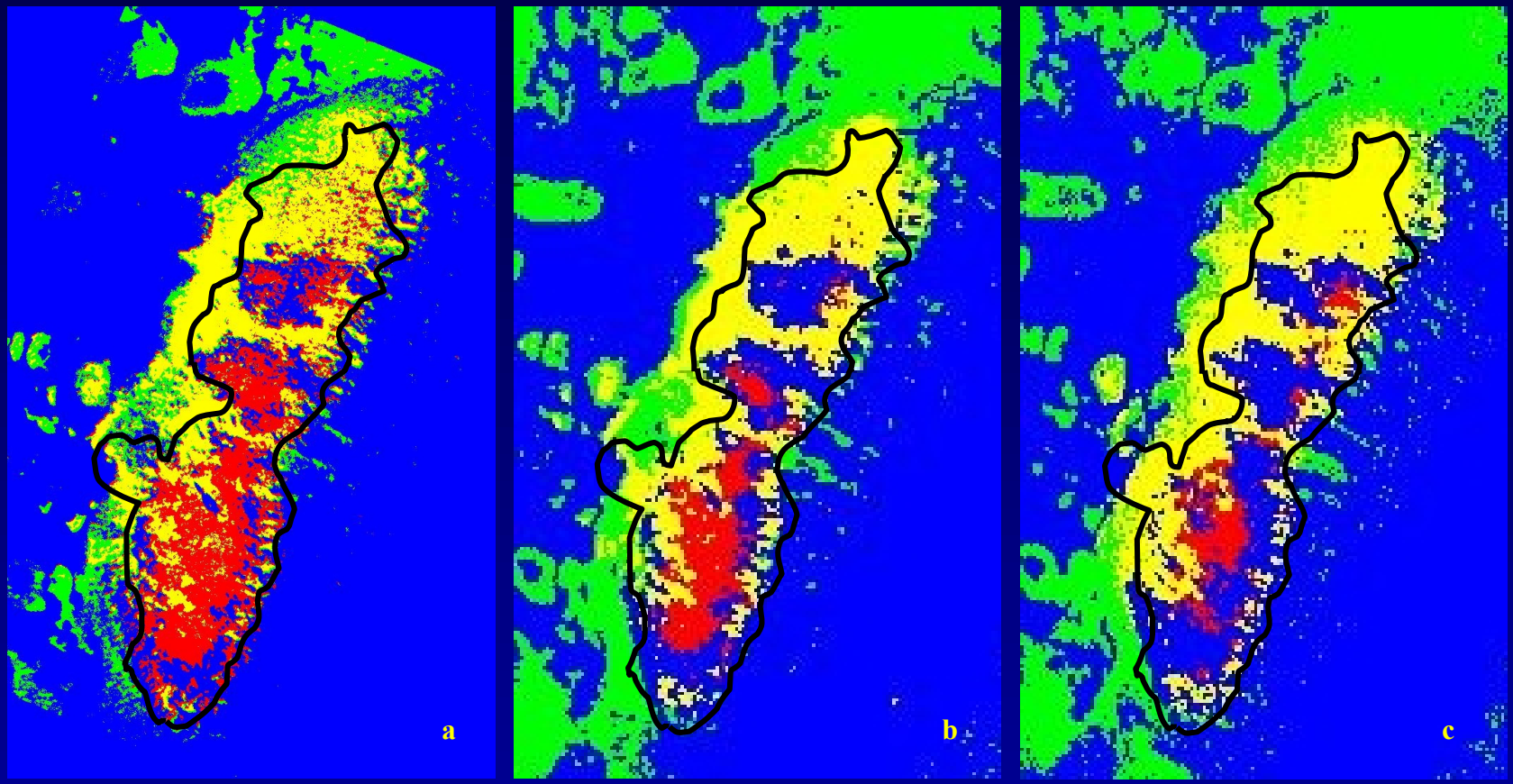
Aerial photo 1982

Aerial photo 1992

Ikonos 2000

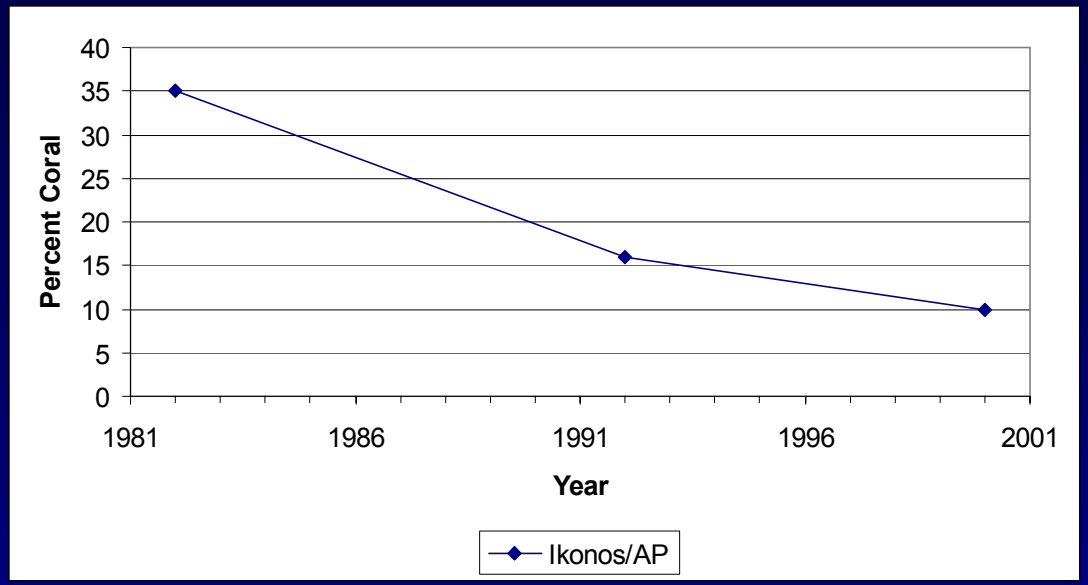
Carysfort Reef, Key Largo, Florida

High resolution change detection

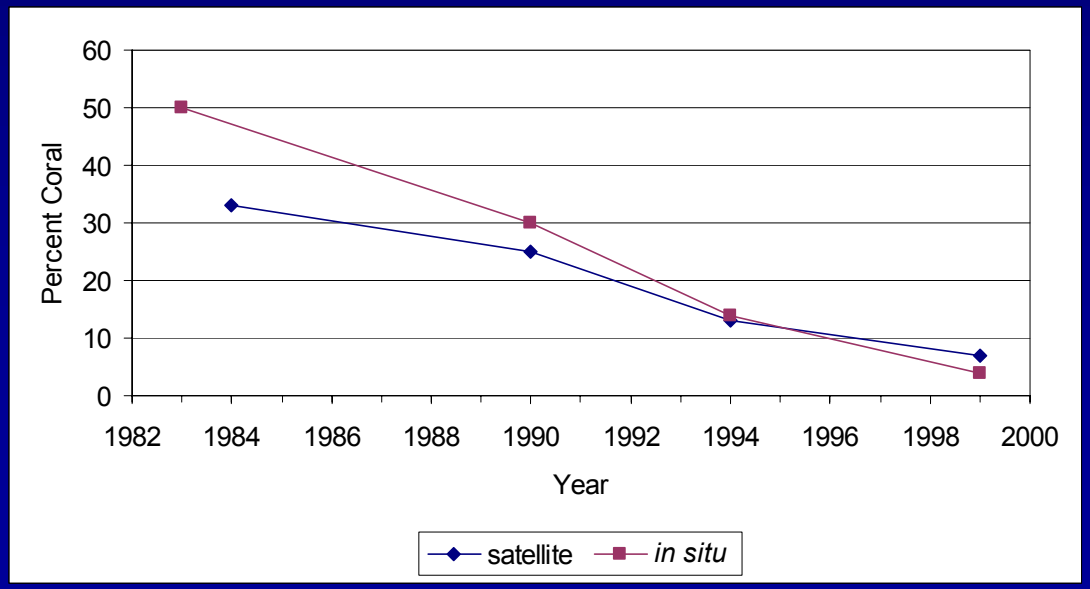


Ref: Palandro D., Andréfouët S, Dustan P. Muller-Karger F. The utilization of Ikonos satellite imagery in conjunction with historic aerial photography to detect change in coral reef communities. Submitted Int. J. Remote Sensing.

Change detection



Aerial photo & Ikonos



TM time-series *vs*
In situ

Community level change detection

Ikonos data coupled with historical aerial photographs can be used to validate change detection performed on TM and ETM+ time-series

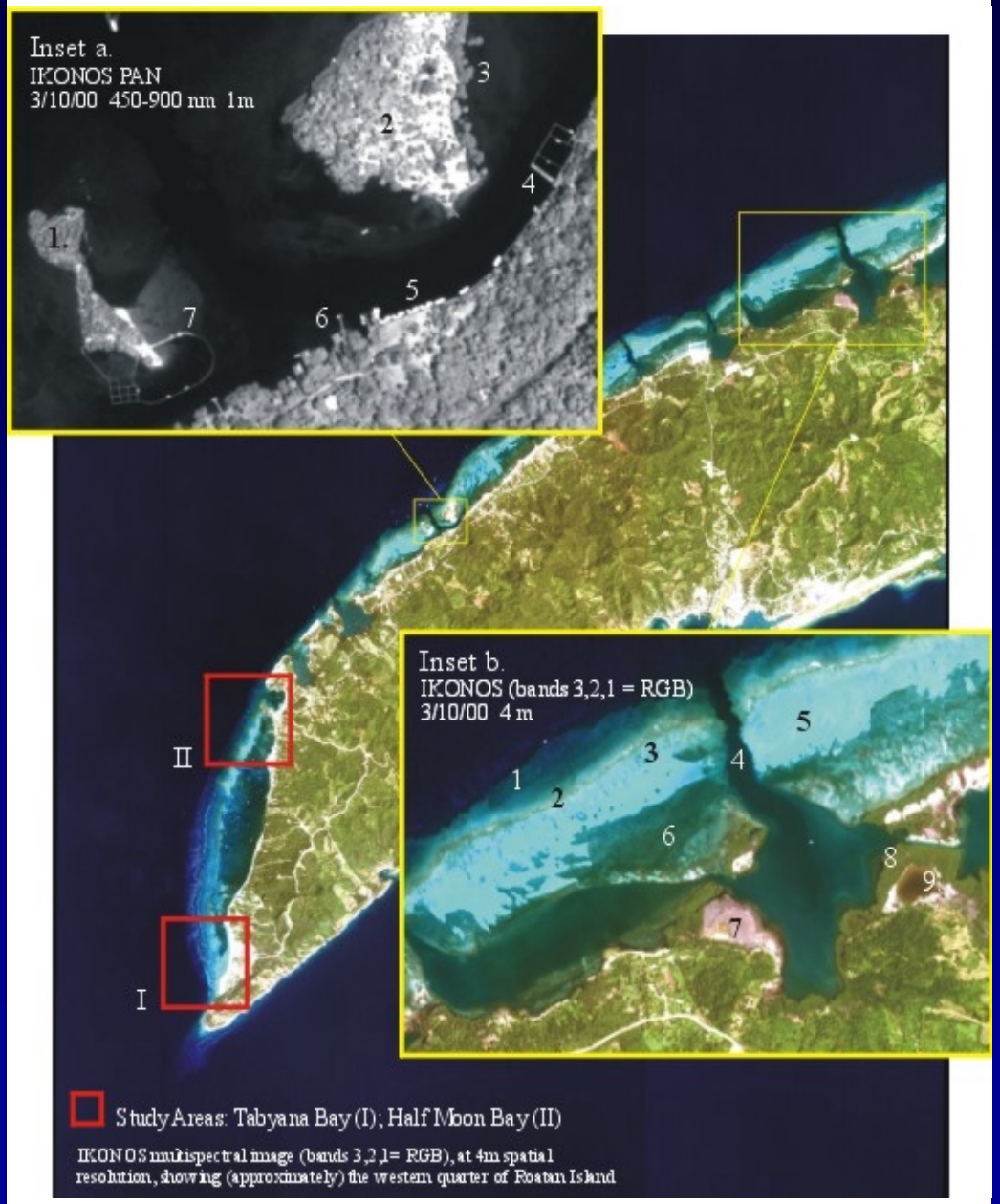
Change detection

Ikonos *vs* Ikonos

Coop. with Univ. Nebraska

1/ Classification image 2000

2/ Classification image 2001 (task in progress)



Change detection

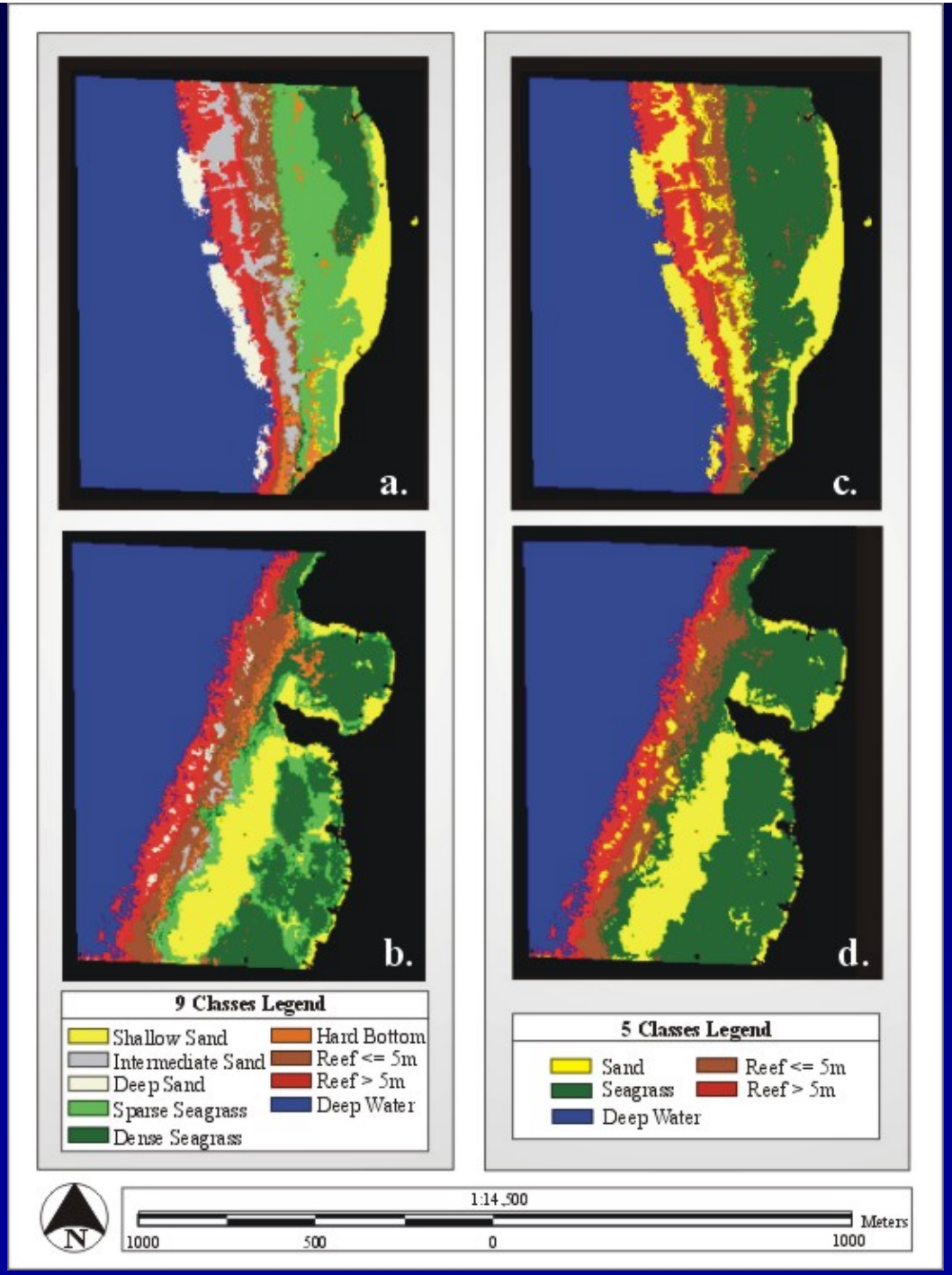
Ikonos *vs* Ikonos

1/ Classification image 2000 (Univ. Nebraska)

overall accuracy: 89%

(Data: Jill Maeder, UN

Ref: Maeder, J., S. Narumalani, J. Schalles, D. Rundquist, and K. Hutchins, 2000. Remote Sensing of Coral Reefs Using High-Resolution Satellite Data. 9th Int. Coral Reef Symposium, Bali, Indonesia.)



Biogeochemistry

- NASA NRA-08 " CARBON CYCLE"

- Coupling in situ & remote sensing (LANDSAT 7 - IKONOS) for reef-scale carbon/carbonate budget for a large number of sites

- Biscayne Bay, Florida (in progress)

4 approaches to process high resolution images

1- Analytical approach (Per pixel)

Relating the measurement to the physical and biological properties of the target (IOP, pigmentation…) using radiative transfer equations

2- Statistical approach (Inter-Pixel)

Clustering pixels according to their radiometric similarity (classification)

3- Spatial approach (Inter-pixel)

Clustering regions of pixels according to spatial properties

4- Artificial Intelligence approach

Transforming human expertise, semantics and symbolism into numerical algorithms

4 approaches to process high resolution images

1- Analytical approach for water targets

- Need calibrated data, excellent radiometric characterization (--> workshop recommendations)

- May need concurrent in situ data during over-pass, difficult to organize in coral reef expedition-type work

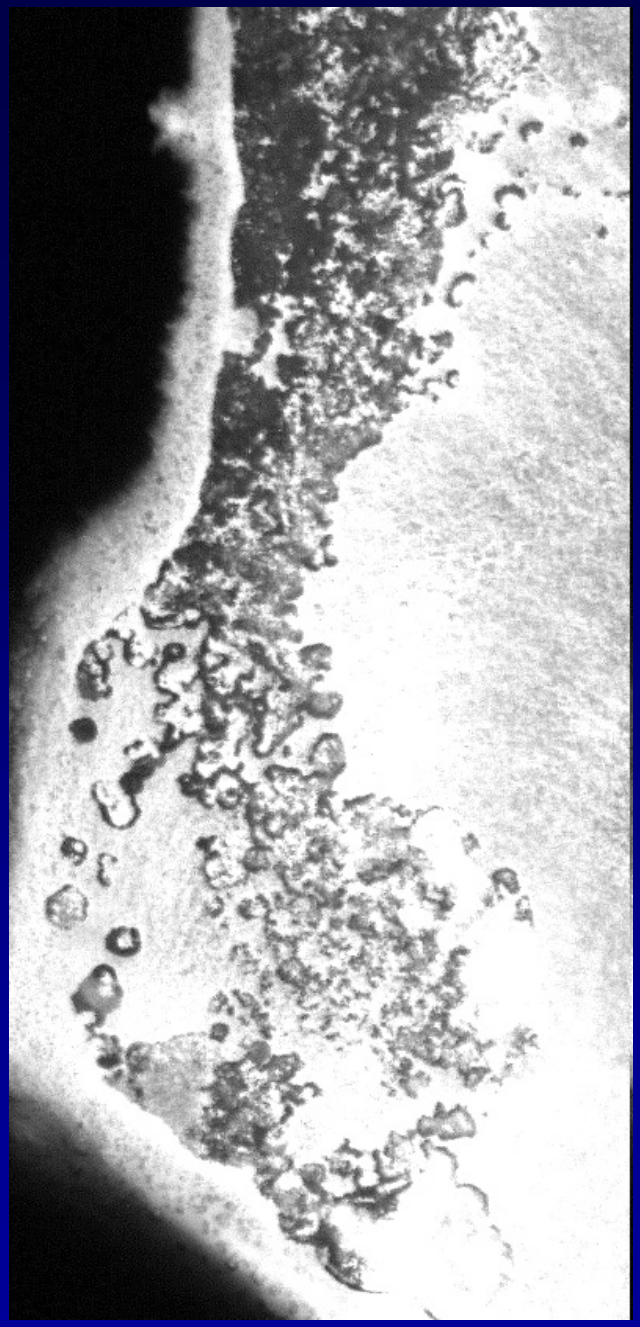
- Need other specifications in tasking requests (wind effects,…)

4 approaches to process high resolution images

2- Statistical approach

- Don’t need calibrated data, except if classification based on statistics acquired on another image (change detection)

- Need large number of training and control areas acquired with specific sampling protocols.



Sampling:

Geometric accuracy of Ikonos products is excellent for field work

Allow random-based (random, cluster, stratified-random,…) sampling with simple means (hand-held GPS)

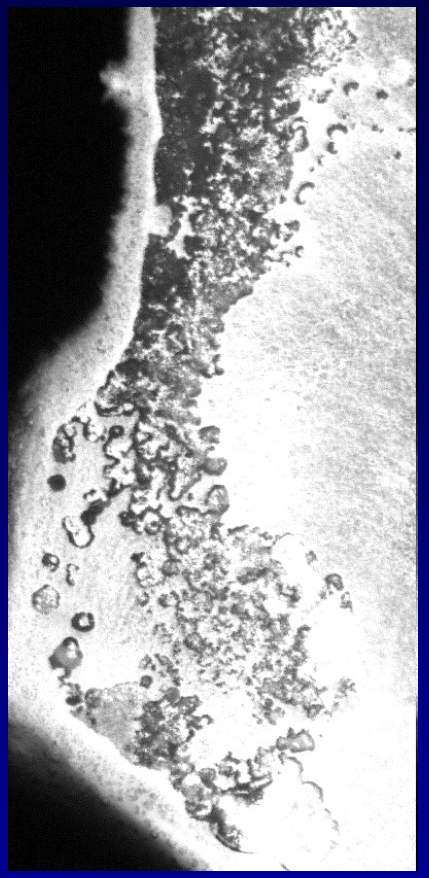
More rigorous accuracy assessment

4 approaches to process high resolution images

3- Spatial approach

- Panchromatic band ???

Useful for seagrass
(high contrast, edge detection techniques)



4 approaches to process high resolution images

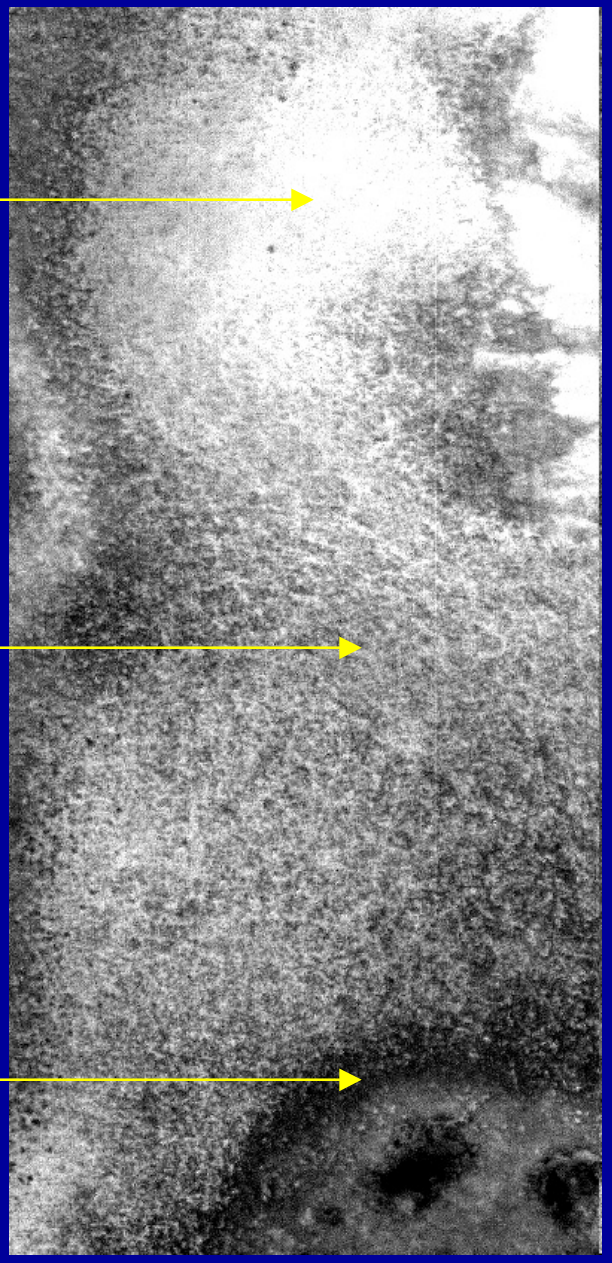
3- Spatial approach

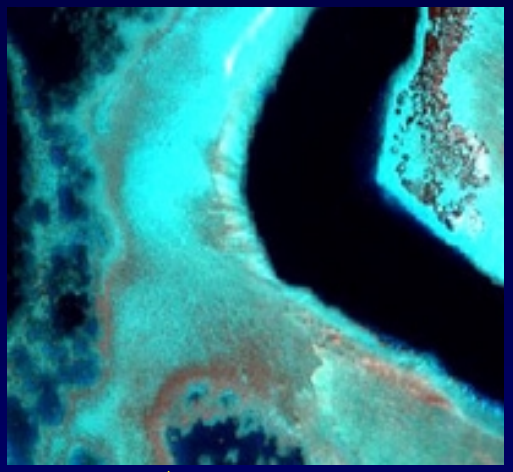
- Panchromatic band ???

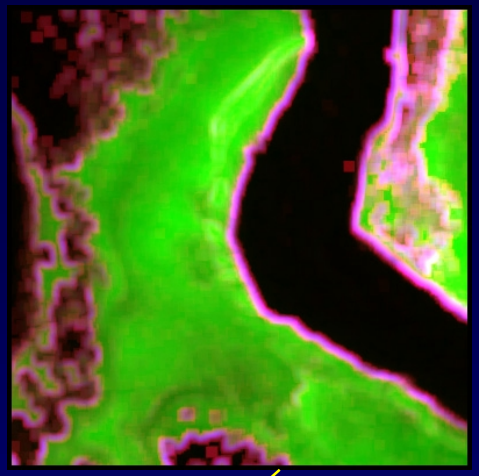
Useless for other communities in most of our images and probably for most of the reefs systems (to be tested for reticulated system)

Test of textural approach for barrier reefs system

Heterogeneous bottoms



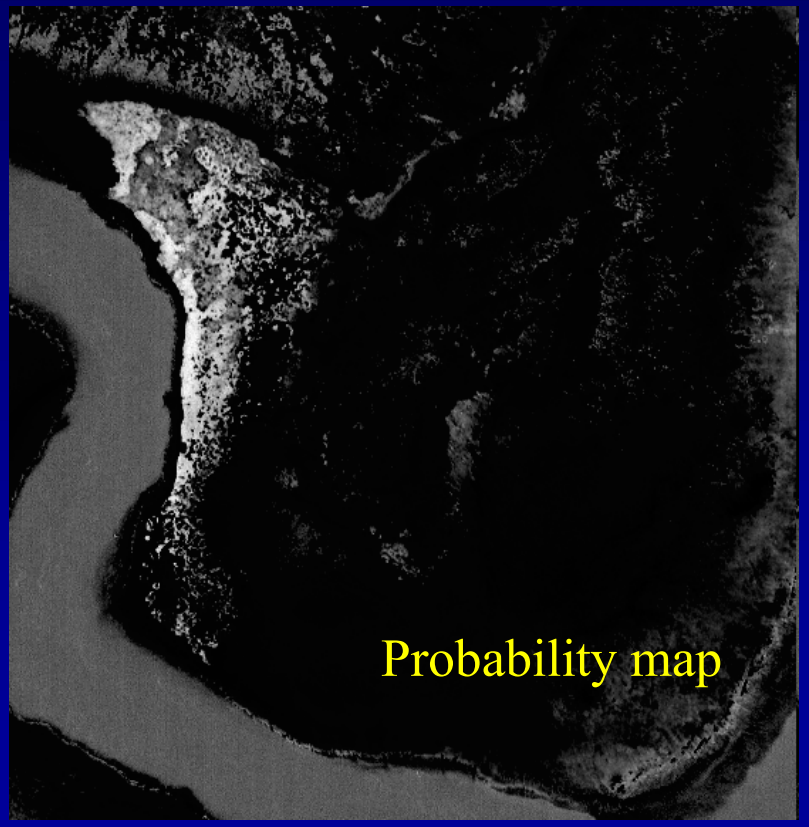




B, G, R, NIR

Texture channels

Fuzzy logic merger
Multi-source fusion



4 approaches to process high resolution images

3- Spatial approach

- Does texture has a significant influence on the level of probabilities?

- FTM Compensation : Influence on texture ???

Answer: IGARSS 2001

Conclusions

Ikonos data useful for various coral reef applications

Methodology:
- Classification
- Needs to investigate analytical methods (atmospheric correction, water correction, ….)

Landsat 7 / Ikonos complementarity

SDP / SI provided great data, but addition of specifications for aquatic ecosystem should be good,
Quick control by SDP team + final user before accepting data

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All of you for your clarifying (and sometimes confusing) information during this workshop